NOVEMBER, 1952

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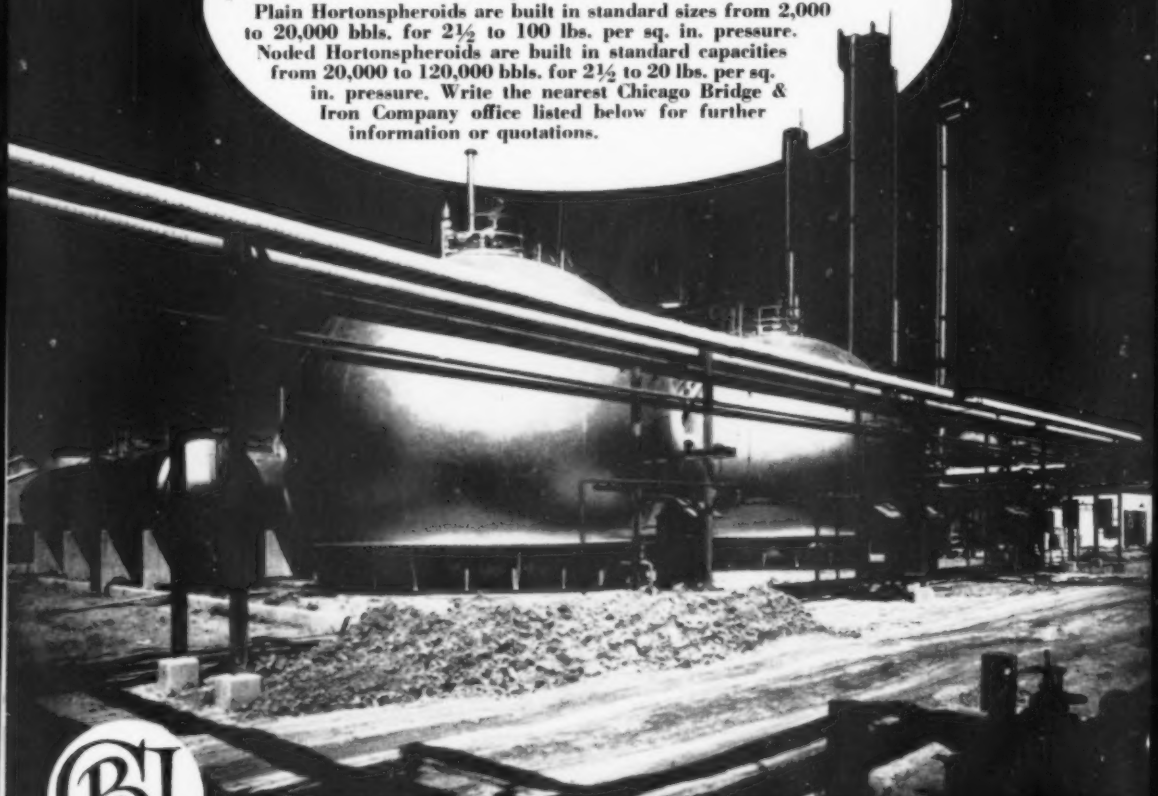
Volatile hydrocarbons are handled and stored under pressure to reduce evaporation loss and protect quality. Hortonspheroids are proving their efficiency every day at hundreds of locations by providing more dependable pressure storage at lower cost. Hortonspheroids reduce evaporation losses caused by breathing or boiling. No vapor can escape as long as internal pressure does not exceed the pressure relief valve setting.

Plain Hortonspheroids are built in standard sizes from 2,000 to 20,000 bbls. for 2½ to 100 lbs. per sq. in. pressure. Noded Hortonspheroids are built in standard capacities from 20,000 to 120,000 bbls. for 2½ to 20 lbs. per sq. in. pressure. Write the nearest Chicago Bridge & Iron Company office listed below for further information or quotations.



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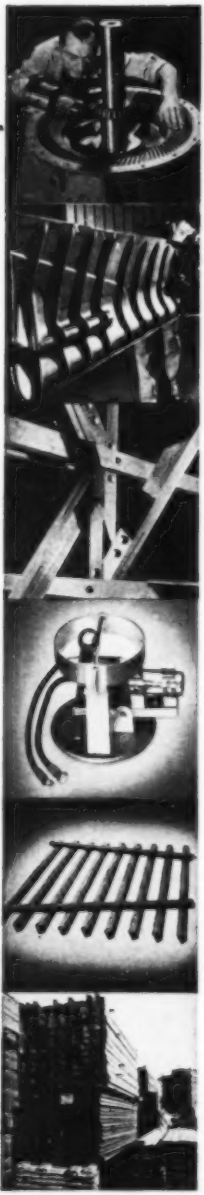
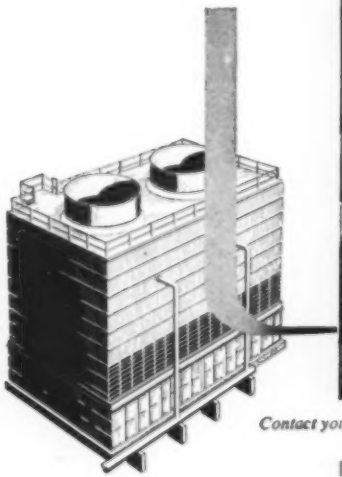


ONLY FLUOR

induced draft counterflo cooling towers provide these 6 exclusive features...



Spiral Bevel Gear Speed Reducers

Only Fluor-Western speed reducers incorporate curved tooth spiral bevel gears as standard design. This proven principle provides quieter, smoother, more efficient operation under the rugged conditions of cooling tower service. Other special design features include: oil-bath lubrication; dry air breather; chrome-plated shaft at oil seals; and, low-speed fan shaft mounted on special steep angle thrust and radial bearings to take combined gear thrust, fan thrust, and weight of fan assembly.

Unique Fan Blade Design

The Fluor Type HC Stainless Steel Fan blades, furnished as standard on every Fluor Counterflo Cooling Tower, are a joint development of The Fluor Corporation and Solar Aircraft Company. Designed specifically for induced draft cooling tower service, their unique air foil handles maximum air volumes at minimum tip speeds and horsepower requirements. Design *plus* mechanical arrangement eliminates recirculation of air and resulting power-consuming turbulence.

Internal Gusset Plate Construction

Fluor Counterflo Cooling Towers alone make full use of tensile as well as compressive strength of structural members! Their internal gusset plate design duplicates that used in wooden bridge construction. These simple, yet extremely strong joint connectors mean longer tower life, lower total tower weight, fewer and simpler castings, greater ease of erection, and minimum spoilage should the structure be dismantled, moved and re-erected.

Patented Vibration Cut-Out Switch

The Vibration Cut-Out Switch developed and patented by Fluor in 1944 protects tower structure and mechanical equipment by stopping the motor should excessive vibration suddenly occur. In addition to its value as an emergency safety device, the switch can be utilized by the operator as a positive "on-off" switch during routine inspection of tower structure and mechanical equipment. The motor cannot be started accidentally once the switch is placed in the "off" position.

Sloping-Bar Grid Decking

Exclusive Fluor-designed sloping-bar grid decks are of rough-finished 1" select redwood machine-nailed to 1" x 2" cleats—strong enough for use as scaffolding during erection, rugged enough to withstand the erosion of falling water. This means low maintenance and replacement cost. The sloping-bar design and arrangement of each deck cross member combines the advantages of maximum deck surface with minimum air pressure drop through tower.

Complete Prefabrication of Structure

Only Fluor Counterflo Cooling Towers are completely prefabricated. This offers many advantages to the operator. Tower parts are "packaged" for rapid delivery, marked for orderly erection. Erection is faster, easier, at lower cost. All cutting, drilling and nailing is completed at the factory. Prefabrication means standardization—low-cost replacement of standard parts that may become damaged over the years. It means uniformity in both performance and appearance.

Contact your nearest Fluor representative for detailed information. You Can Be Sure With Fluor

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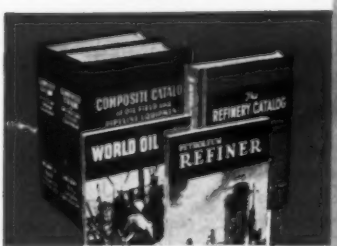
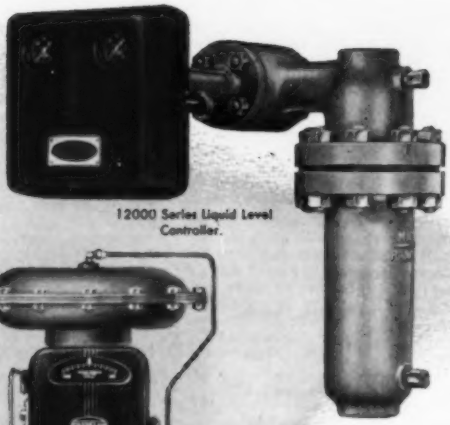
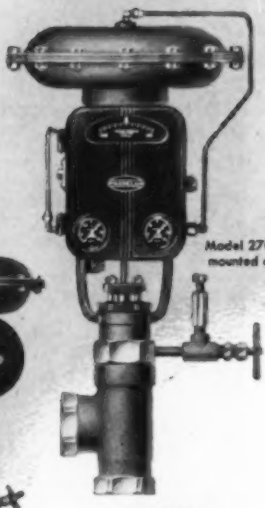


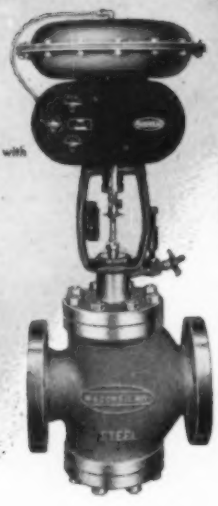
Indicating, non-indicating and recording pressure, temperature or flow controllers.



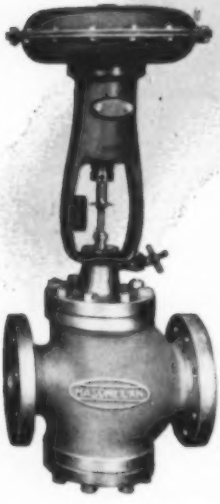
12000 Series Liquid Level Controller.



Model 2707 Pressure Controller mounted on control valve.



10000 Series Control Valve with Series 7400 Positioner.



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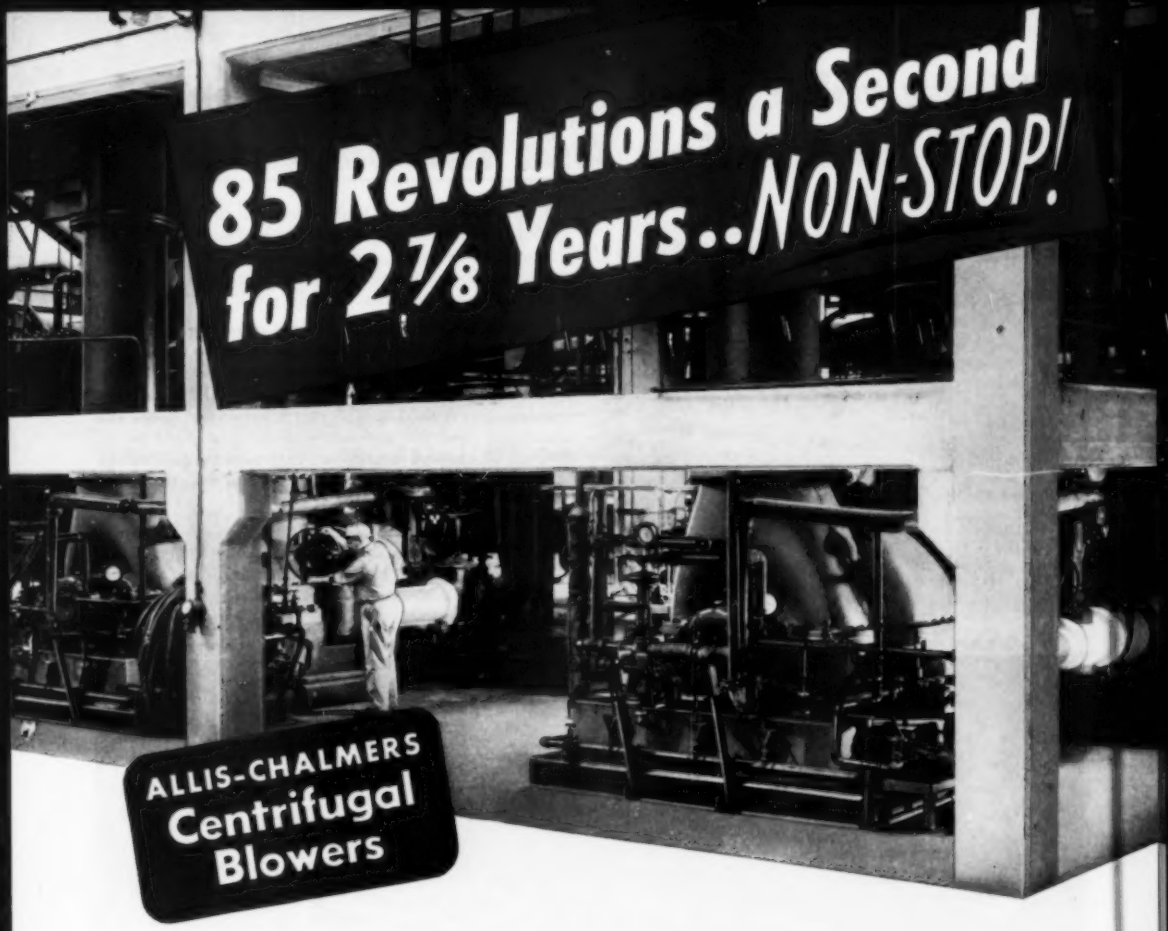

GIVE RECORD PERFORMANCE AT CITIES SERVICE REFINING CORPORATION

AROUND THE CLOCK fluid catalytic cracking service *demands* reliable equipment. Cities Service Refining Corporation at Lake Charles, La. depends on seven Allis-Chalmers centrifugal blowers for catalyst aeration . . . rated 22,500 cfm, 17 lb G at 5100 rpm.

Six of the seven were installed in 1943. Two proceeded to set a record of 540 days, 24 hours a day, continuous operation — being shut down only for drive inspection! Two others have since run for 1058 days before scheduled inspection shutdown! Only routine maintenance has been required.

These blowers are still on the job, 24 hours a day, helping produce motor, premium, aviation gasoline and other fuels for the widespread operations of Cities Service Refining Corporation. Output is at constant volume, maintained by variable speed steam turbines.

Here are the reasons for the low maintenance and high dependability of A-C centrifugal blowers:

PURE ROTARY MOTION — precisely balanced impeller is only moving part.
FRICTION FREE INTERIOR — bearings outside casing, no internal mechanical wear.
SIMPLE LUBRICATION—oil under pressure in closed circuit, consumption is low.
STRONG CONSTRUCTION — forged steel shaft, alloy impeller cuts unit size, weight.
CAST IRON CASING — cast construction makes blower rigid, smooth, quiet.
THOROUGH TESTING — maximum and severe over-speed tests given at factory.

For more information or literature on this kind of highly dependable, low maintenance air and gas handling equipment, call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wis. New Multi-Stage Bulletin 19B6104A now available.

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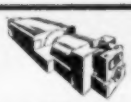
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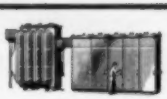
BLOWERS and COMPRESSORS

TRANS-FORMERS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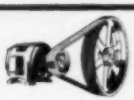

MOTORS—*TEXROPE* DRIVES-CONTROL

CENTRIFUGAL PUMPS

What tube steel gives you the best life/cost ratio? Ask the experts!

This month's report is on: **2% CR.-MO.**

Has intermediate corrosion resistance in combination with good creep strength and fair resistance to oxidation. For use at temperatures up to 1200° F. in cracking coils, reforming units, heat exchangers, vapor line and hot oil piping, and return-bend forgings for oil heaters.

23 TIMKEN® STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3*
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20*
DM-2	2¼% Cr.-1% Mo.	Sicromo 7	25-12*
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

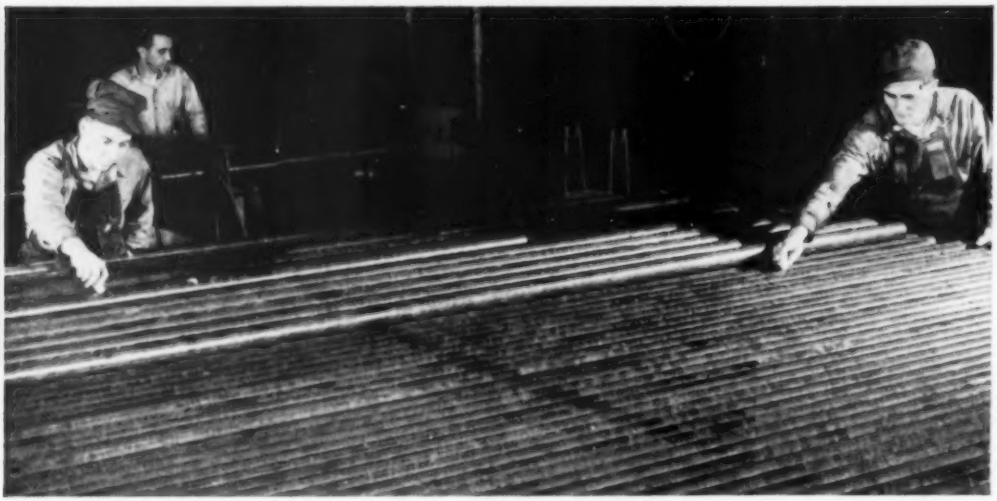
*Not available as seamless tubing at the present time.

MAYBE you can find several high temperature tube steels that will solve your particular set of heat, pressure, corrosion and oxidation problems. But there's only *one* steel that will give you maximum tube life per dollar—the best life/cost ratio.

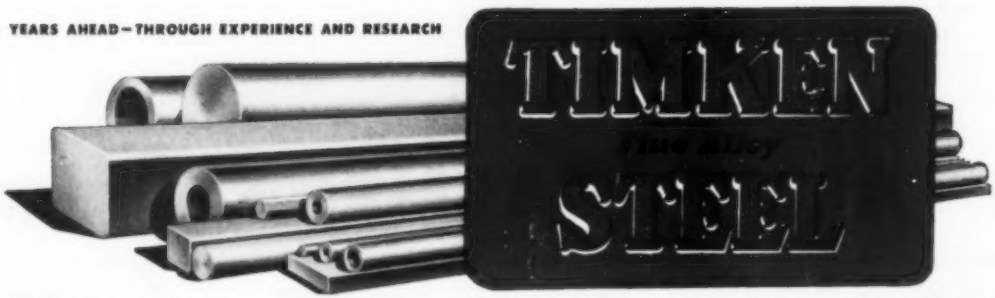
To find that one steel, go to the metallurgists of The Timken Roller Bearing Company. They're recognized authorities on high temperature steels. Backed by 20 years' experience and research and with 23 different analyses at their disposal, they'll help you choose the one best steel for your application. And you'll be assured of uniform quality in every tube because of the Timken Company's rigid quality control from melt shop through final inspection.

Our "RSQ"—Research, Supply, Quality—can solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

Photo below shows final tube inspection—last of hundreds of rigid tests that help account for the uniform quality of Timken high temperature steels.



YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



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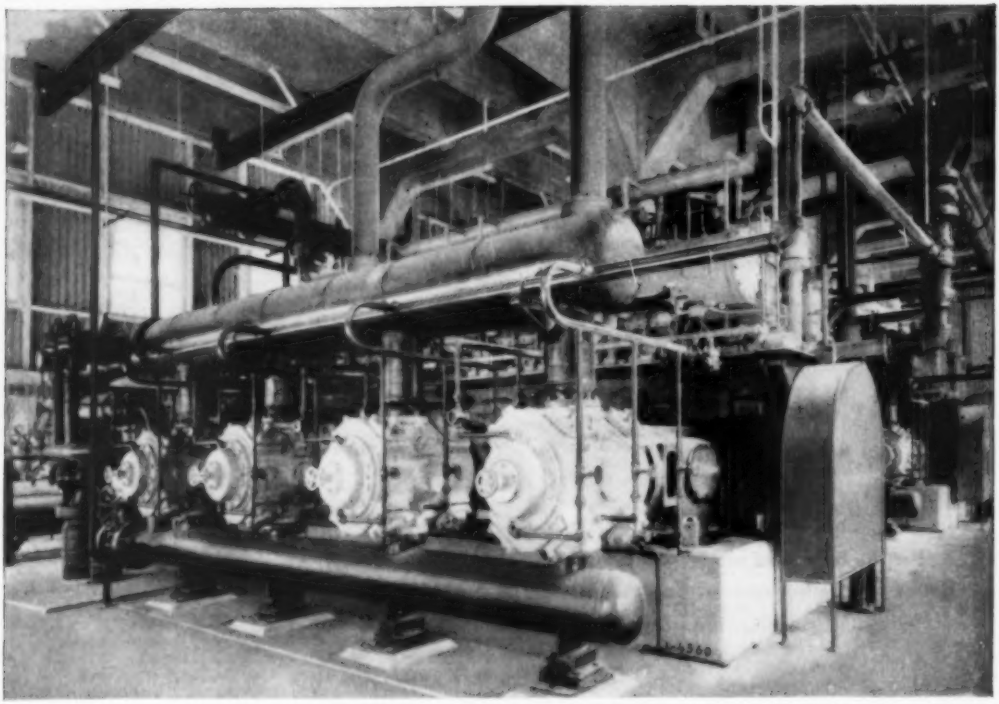


WORTHINGTON ANGLE GAS-ENGINE COMPRESSOR installation in a gas pipeline pumping station.

Now . . . more horsepower, higher efficiency in Worthington Angle Gas-Engine Compressors

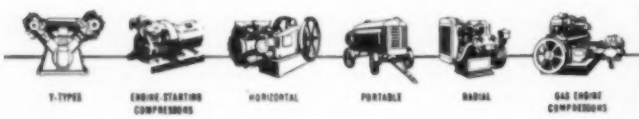
New LTC-H compressor has all advantages of famous LTC plus high compression

This new Worthington LTC-H Angle Gas-Engine Compressor—the latest Worthington advance in its engine-compressor design—is typical of the kind of improvement achieved by Worthington engineers throughout many years of leadership in the manufacture and application of compressors and large internal combustion engines.

The new high-compression engine-compressor has considerably higher horsepower ratings than its well-known predecessor, the LTC, but runs cooler and on less fuel. LTC-H users will find the new unit is built to give the same day-in, day-out service that has given all Worthington Engine-Compressors a reputation for extreme dependability throughout the gas, petroleum and chemical worlds in *pipeline pumping, refinery operations, public utility gas distribution,* and service in *natural gasoline and pressure maintenance plants, petro-chemical and synthesis plants,* and *refrigeration plants.*

Write for more information on this latest development in Bulletin L-690-B1B or let us know that you're interested in conversion of your present unit. Worthington Corporation, Compressor Division, Buffalo, N. Y.

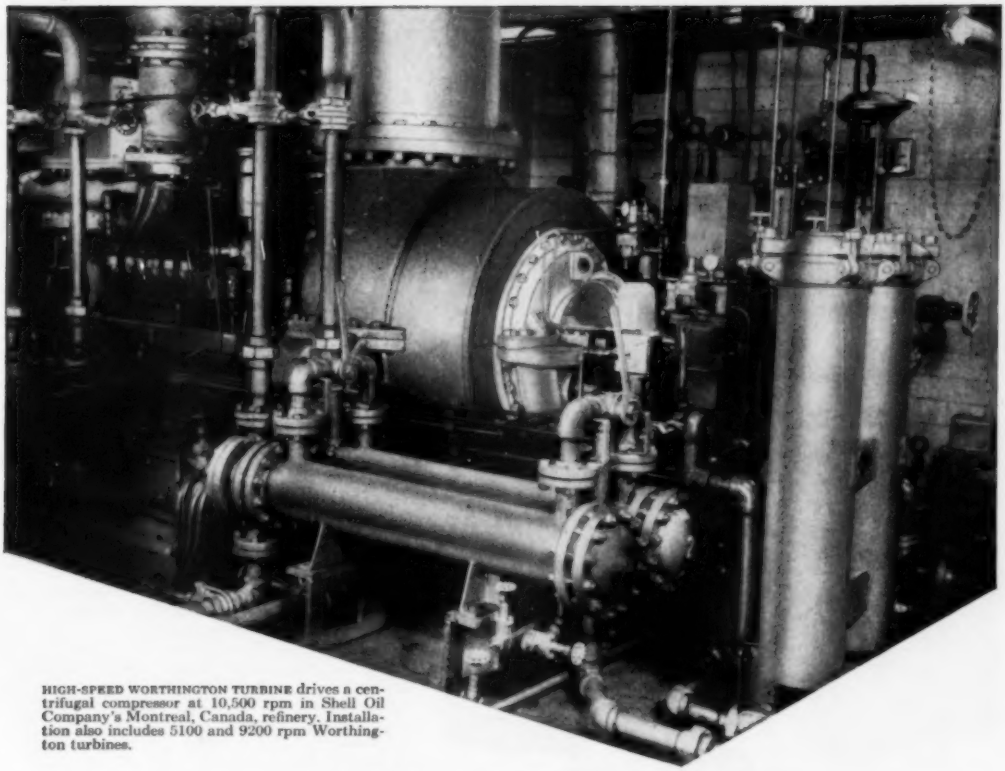
K.2.16



NO OTHER COMPRESSOR WILL OUTPERFORM A WORTHINGTON

WORTHINGTON

Engine Compressors



HIGH-SPEED WORTHINGTON TURBINE drives a centrifugal compressor at 10,500 rpm in Shell Oil Company's Montreal, Canada, refinery. Installation also includes 5100 and 9200 rpm Worthington turbines.

10,500-rpm turbine is third Worthington Compressor Drive Turbine installed at Shell Oil's Montreal refinery

It was in 1950 that Shell Oil built its new big catalytic cracking unit in Montreal.

And it was three high-speed Worthington steam turbines they chose to drive the very vital blowers and compressors. The 10,500-rpm turbine, like the other two, is so free of vibration that after two years of operation its speed can barely be detected on a vibrating-reed tachometer.

Cat-cracker service requires continuous 24-hour-a-day operation so that reliability is of prime importance. Such operation is typical with Worthington centrifugal compressor and blower drive turbines. But it's not the only reason they're preferred in hundreds of plants outside as well as inside the U. S. A.

With a high-speed Worthington steam turbine you can forget costly speed-increasing gears. You easily set the exact speed needed with various types of control and governing arrangements designed specifically for your requirements. Steam consumption is at a minimum, maintenance requirements are simple.

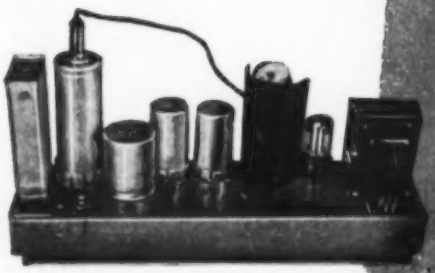
Write for Bulletin 1966 entitled "High Speed Turbines for Your Centrifugal Compressor and Blower Drives." Worthington Corporation, Steam Turbine Division, Wellsville, New York. T.2.10

A GREAT TEAM IN STEAM

WORTHINGTON

Steam Turbines

A lot of Engineering for an Amplifier, but...



Good engineering shows in this Amplifier's wide range of sensitivities, and of impedances, thorough filtering and plug-in connection to the rest of the Speedomax instrument.

Good engineering shows in this Converter's phenomenally low noise level and in its long-lived performance.

Good engineering shows in this Slidewire's non-inductive winding and in absence of any flexible leads which might form inductive loops.

Good engineering shows in this balancing motor's small size, and in its torque ample to operate accessory control and signalling fitments.

it helps Speedomax to fit <u>your</u> ideas!

• Your needs and ideas put this electronic "tool" to work on an amazing variety of jobs. Controlling furnaces and peering into atoms; counting bottles and spying on the weather; taking the "shine" out of rayon or putting it on hardware, to name six out of thousands of uses. For, in general, if you can feed Speedomax a tiny electrical signal, representing the condition you wish to measure, the instrument will not only put "calipers" on it, but will amplify it enormously to direct anything that can be directed through electrical or pneumatic means.

The Speedomax way of handling this job provides particularly accurate results and an especially good fit in meeting your individual ideas. For instance, there's the matter of receiving the signal in a way suited to its size—or, more usually, to its smallness.

We have no less than twenty-three carefully-engineered Speedomax Amplifiers covering a wide range of sensitivity and impedance levels. One Amplifier in the series enables the Speedomax to respond to a signal of only 10-16 watt—one ten-billionth of a microwatt. No other recorder amplifier comes within 3 magnitudes of this figure. Such sensitivity means corresponding accuracy in detecting the tiny unbalance—called "error" by circuit engineers—which actuates the rebalance system.

In terms of power, all 23 Amplifiers deliver the same—5 or 6 watts. This is from 2 to 4 times the output of other recorder amplifiers; permits a more powerful balancing motor. And the Amplifier-Motor team provides an especially high torque gradient just where it's needed—centering around the balance point—for prompt, positive balancing and easy, effortless operation of a "heavy" load of control or signal devices in the motor shaft.

The Speedomax story for industry is told in Catalog ND46(1); for Research, in Tech. Pub. ND46(1). We will send either on request; address our nearest office or 4923 Stenton Ave., Phila. 44, Pa.

LEEDS [LN] **NORTHRUP**

instruments — automatic controls • furnaces

Jrl. Ad. ND46(7)

CAREER OPPORTUNITIES AT L&N

Expansion program of this long-established firm has many features to attract outstanding recent graduates in engineering and science. Opportunities are in sales field engineering, product and application engineering, research, advertising, market development. Widely-respected policies assure recognition of progress and achievement. Address Personnel Manager for preliminary interview at nearest of 17 L&N offices.

The success of Procon in handling a broad range of process construction jobs is assuring evidence of the satisfaction you may expect from any Procon project.

Ability, experience, flexibility and attention to detail are among the many factors that make the name Procon synonymous with practical and efficient construction service on any job — large or small.

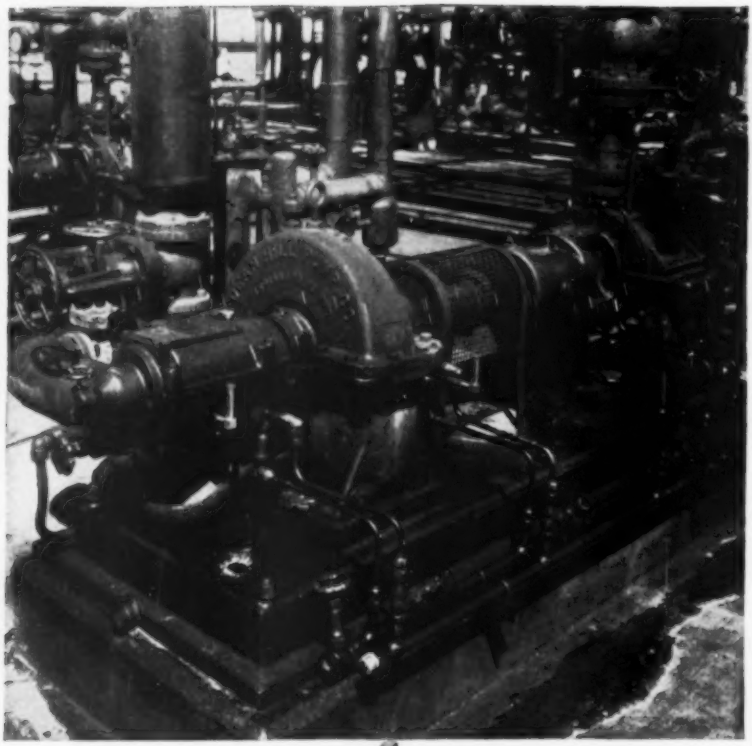
Whatever processing facilities you require — Platforming units, fluid catalytic cracking units, visbreakers, gas recovery systems or, in fact, any type of units or plants — you can place complete confidence in Procon.

PROCON

PROCON *Incorporated*

PROCESS CONSTRUCTION

1111 MT. PROSPECT ROAD, DES PLAINES, ILL., U.S.A.

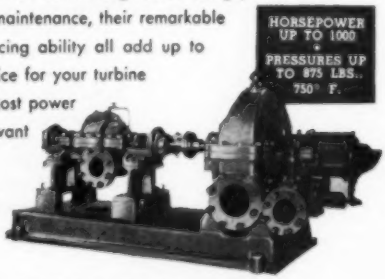


DEAN HILL STEAM TURBINES

are single stage, double impact type for low steam consumption. Specifically designed for operation at medium steam pressures and temperatures, DH Turbines have all the advantages available under these conditions, including excellent water rates. Get the full details and complete specifications. Write today.

POWERFUL "PENNY PINCHER"

Power a-plenty at a penny-pinching cost! That's how DEAN HILL STEAM TURBINES operate. Their super rugged construction, their service-engineered design, their low maintenance, their remarkable power-producing ability all add up to far more service for your turbine dollar. If it's low cost power you want . . . you want DEAN HILL STEAM TURBINES.



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Pump and Turbine Engineers Since 1895

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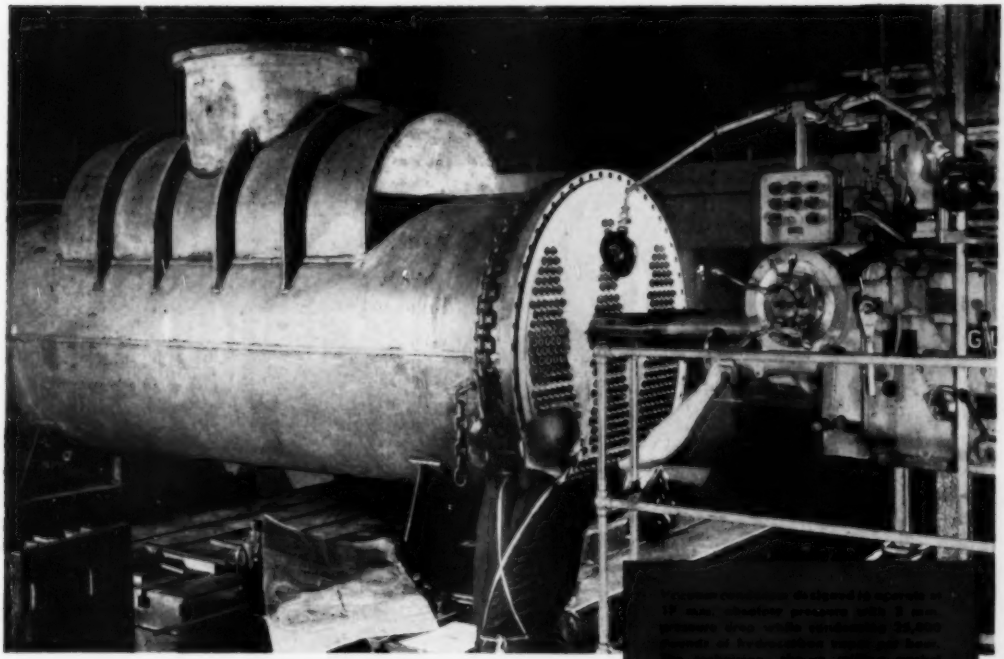

SPECIAL Heat Exchangers

FOR CUSTOMERS' PROCESS REQUIREMENTS

Shown nearing completion is the A. O. Smith solution to one of its customer's heat exchanger problems. Starting with only the process conditions, the condenser was designed and manufactured in its entirety by A. O. Smith.

Successful design of the exchanger to meet critical process requirements necessitated a special tube arrangement to provide minimum pressure drop, and inlet nozzles to give maximum distribution of vapors throughout the entire length of the condenser.

For the design and manufacture of special equipment to solve special process conditions, like the above, A.O. Smith has a corps of experienced research, engineering and manufacturing groups. For over 25 years they have been serving the petroleum and chemical industries, accumulating invaluable experience, data and skills which *YOU* may depend on to help solve *YOUR* heat exchanger and vessel problems.

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Research and Engineering Building

INDUSTRY COMES TO A. O. SMITH WITH HEAT EXCHANGER PROBLEMS

Reduce slag ... increase production

with the

Ljungstrom Air Preheater

Slag – primary cause of reduced capacity – can be practically eliminated by the use of a Ljungstrom Air Preheater.

That's because preheated air mixes more thoroughly with the fuel. Therefore, less excess air is required for complete combustion – and less combustible material is lost in the flue gases.

Thus, with a Ljungstrom Air Preheater, there is less material present in the furnace for slag production. Oil tubes stay cleaner . . . longer. Stills stay on stream *at top production* for months longer.

For example, a pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom Air Preheater and modern high-temperature burners, the still operates *continuously at 18,000/20,000 barrels.*

This saving alone can pay for a Ljungstrom installation in less than a year. Add it to more economical furnace design possible . . . up to 20% fuel savings . . . greater heat recovery even from low grade fuels . . . higher throughput – and you can see why the Ljungstrom Air Preheater is perhaps *the most significant guidepost to economy available today to refiners.*

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in your fuel burning equipment—call or write The Air Preheater Corporation today.

THE AIR PREHEATER CORPORATION

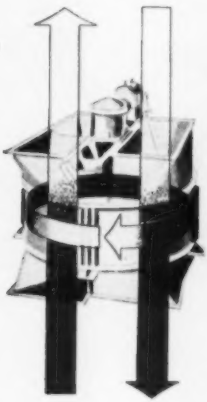
60 East 42nd Street, New York 17, N. Y.

Refineries Now Using the Ljungstrom Air Preheater on One or More Process Units . . .

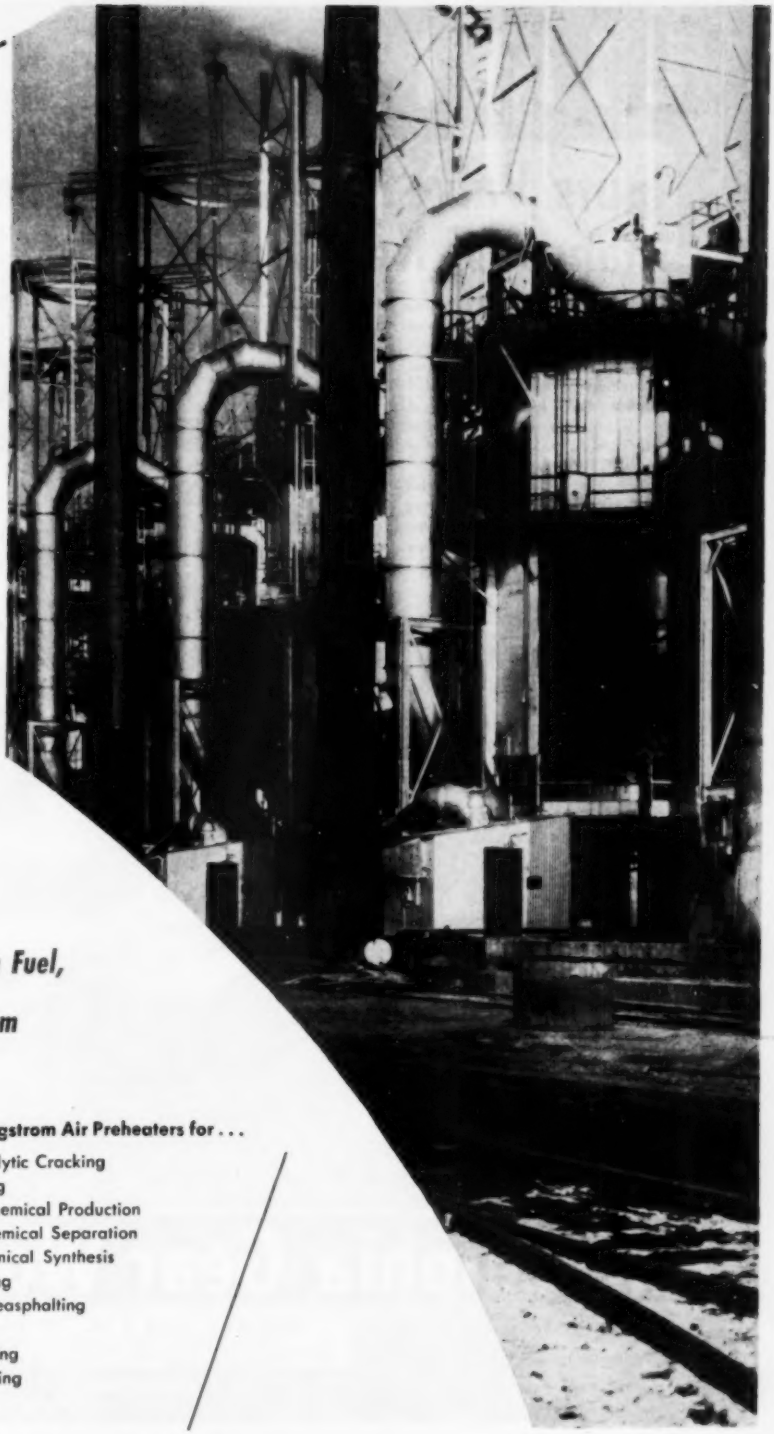
Continental Oil Company
Interocean Oil Company
Le Conselho Nacional de Petroleo Ref.
Lion Oil Company • Ohio Oil Company
Richfield Oil Corporation
Sinclair Refining Company
Socony Vacuum Oil Company
Standard Oil Company of California
Standard Oil Company of New Jersey

The Ljungstrom is no stranger to refineries. For years it has been a standard item for utilizing waste heat from power and process steam boilers. These refiners now use Ljungstrom Air Preheaters on steam boilers . . .

Cit-Con Oil Corporation • Continental Oil Corporation
Esso Standard Oil Company • Humble Oil & Refining Company
Magnolia Petroleum Corporation • Pan-American Refining Company
Phillips Petroleum Company • Shell Oil Company
Standard Oil Company of Indiana
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey • The Pure Oil Company
The Texas Company • Tidewater Associated Oil Company
Wilshire Oil Company



The Ljungstrom operates on the continuous regenerative counter-flow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



Wherever You Burn Fuel, You Need Ljungstrom

Consider Ljungstrom Air Preheaters for . . .

Catalytic Cracking
Coking
Petrochemical Production
Petrochemical Separation
Petrochemical Synthesis
Polyforming
Propane Deasphalting
Reforming
Solvent Refining
Thermal Cracking
Visbreaking

LIMITORQUE

puts Valve Operation in the hands of Key Workers

Refinery and pipe line valves of all types can be opened and closed quickly and safely with LimiTorque. Conveniently located push button stations are the control centers from which even remotely located valves may be operated by highly responsible employees. It is unnecessary to entrust important valve operations and valuable equipment to men chosen for brawn alone.

Operators know exact position of each valve at all times by indicating lights.

LimiTorque functions properly under all climatic conditions. Actuation may be by electricity, air, natural gas, or any other available power source.

OUR 60TH ANNIVERSARY

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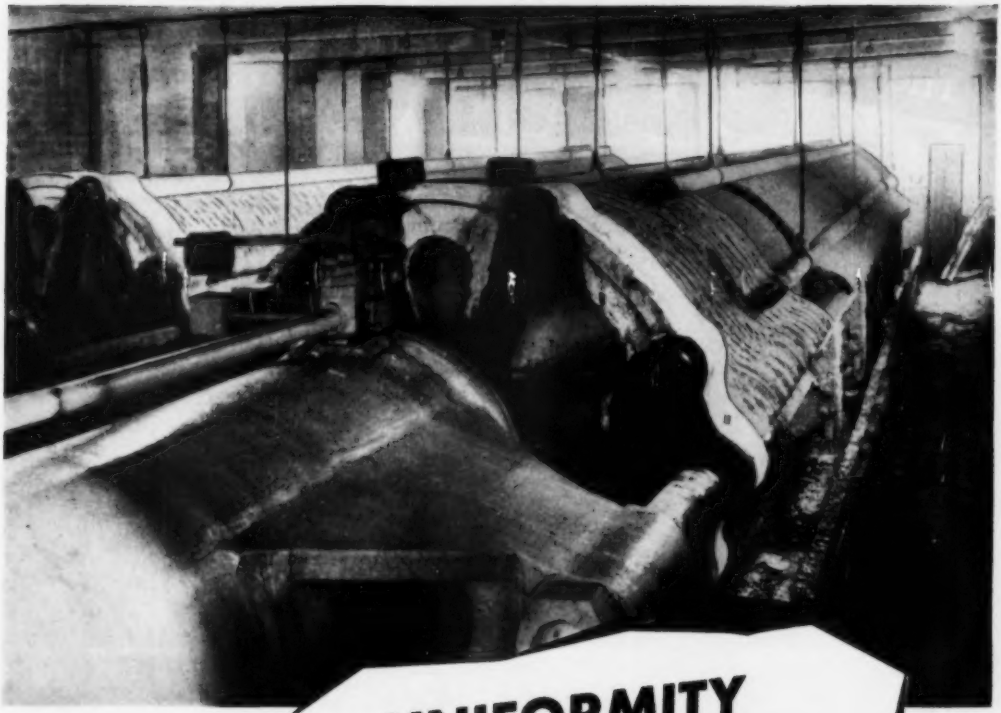
Industrial Gears and Speed Reducers
LimiTorque Valve Controls



UNIFORMITY
Makes the Big Difference
In FILTER Fabrics

Gives You Greater Fabric Uniformity

Determining yarn tensile strength with 300-lb. vertical test.

One of a series of comprehensive laboratory controls throughout production to assure uniformity in all Mt. Vernon-Woodberry products.

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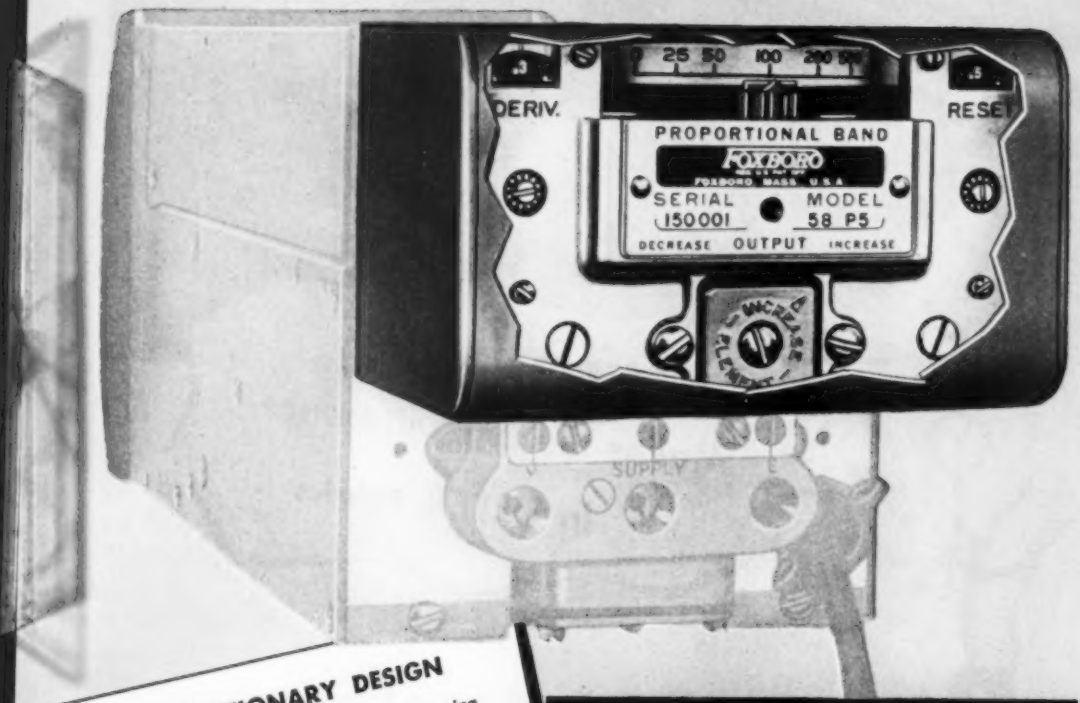
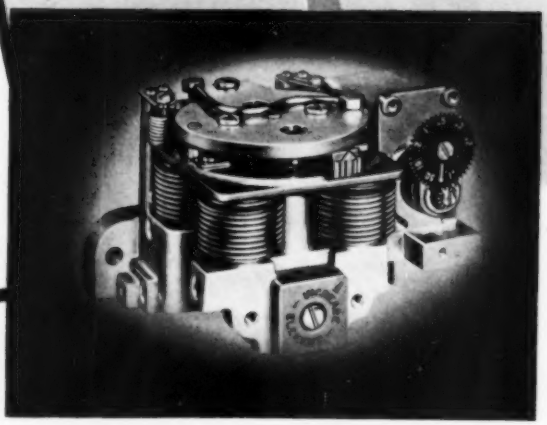
The New CONSOTROL

Radically new operating principle . . .
Simplest Installation

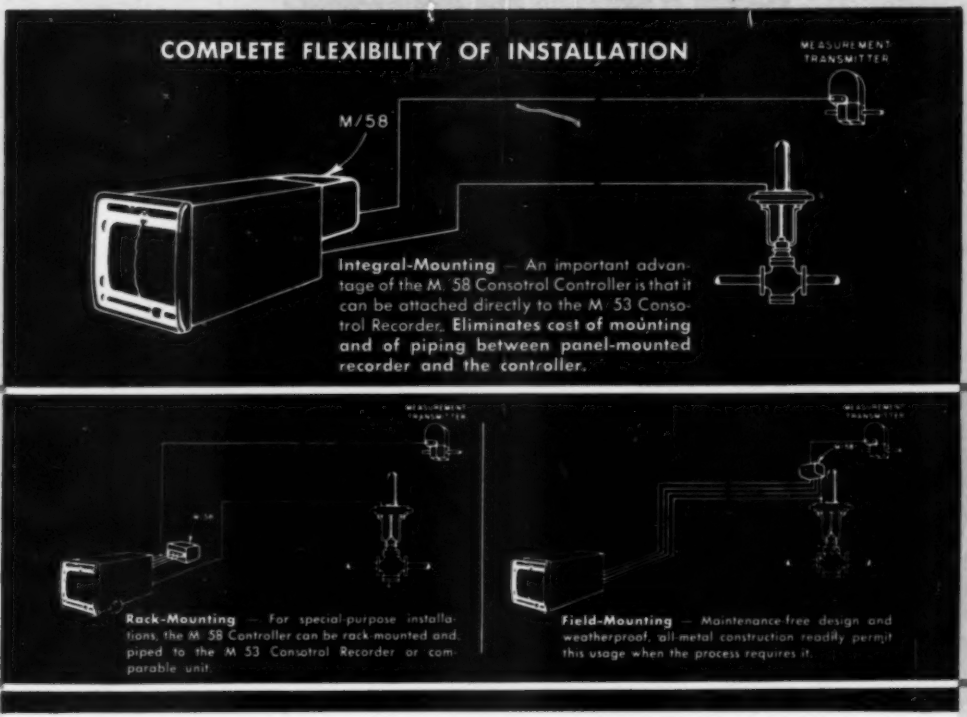


REVOLUTIONARY DESIGN

The unique Foxboro "floating-disc" balancing system is shown at right with dial-set reset unit. Dial-set derivative unit is plugged in at left of assembly (see above). Conversion from proportional to reset and/or derivative action can be made in the field, in a matter of moments, with only a screwdriver! New design adjustable restrictors provide 1000-1 rangeability, perfect reproducibility, and consistent rates on both increasing and decreasing air pressure. Proportional band is a lever setting, fully adjustable from 0 to infinity.



M/58 CONTROLLER


COMPLETE FLEXIBILITY OF INSTALLATION
MEASUREMENT TRANSMITTER
M/58
Integral-Mounting — An important advantage of the M/58 Consotrol Controller is that it can be attached directly to the M/53 Consotrol Recorder. Eliminates cost of mounting and of piping between panel-mounted recorder and the controller.
Rack-Mounting — For special-purpose installations, the M/58 Controller can be rack-mounted and piped to the M/53 Consotrol Recorder or comparable unit.
Field-Mounting — Maintenance-free design and weatherproof, all-metal construction readily permit this usage when the process requires it.

Over and above its extreme compactness for graphic panel use, the new Foxboro M/58 Consotrol Controller offers unique advantages in its simplicity of design, unmatched performance, and ease of installation.

This Controller employs an exclusive, simplified balancing system in which the measurement, proportional, reset, and derivative bellows act on a single "floating-disc". With no diaphragms, only one nozzle, and only one moving part, it gives control action unrivalled in stability, sensitivity, and with positive, drift-free control point.

Installation, also, is radically simplified. The M/58 is designed to attach directly to the M/53 Consotrol Recorder (eliminating cost of piping and mounting) or, optionally, to be mounted in remote locations if required.

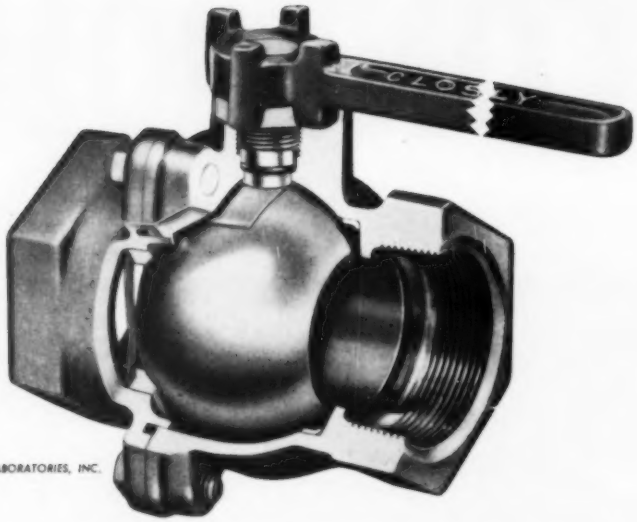
Write for Bulletin 463 containing full details of the M/58 Controller together with the full line of Consotrol Instruments. **The Foxboro Company, 7411 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities.

FOXBORO instruments

Reg. U.S. Pat. Off.

INDICATING • RECORDING • CONTROLLING

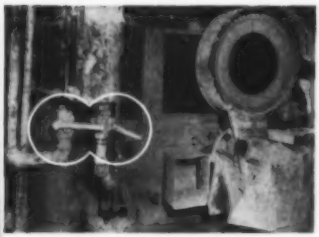
FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND



TESTED BY UNDERWRITERS' LABORATORIES, INC.

Breaking Records Throughout Industry!

FOR LONG LIFE . . . FOR ECONOMY . . . FOR SAFETY



Leading glass manufacturer reports Rockwood Ball Valves, operated 1500 times a day in a mixing process, were *only valves to stay in service over a year.*

Maintenance engineer of large gas company says: "Easy operation and no maintenance cost make Rockwood Ball Valves *far ahead of any others we have used.*"

On Texas transport firm's fleet of propane-butane trucks, the leakproof construction of Rockwood Ball Valves make them *safest for handling inflammable gases.*

Here's why Rockwood Ball Valves give you more of what you want in valve performance:

FULL ROUND FLOW . . . no change in shape or volume of the fluid stream . . . no turbulence . . . minimum friction loss.

QUICK OPENING AND CLOSING . . . needs only a quarter turn, even under full pressure.

RESISTS WEAR LONGER . . . scratching, pitting and abrasion have little effect on the chrome-plated, floating bronze ball.

STAYS LEAKPROOF . . . in closed position, pressure of fluid automatically positions ball against synthetic rubber seat to form a tight seal.

It will pay you to investigate how these advantages can benefit your own applications. Send for bulletin. Rockwood Sprinkler Company, 102 Harlow Street, Worcester 5, Mass. Distributors in all principal cities.

Some Prominent Users

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Revere Copper & Brass, Inc.
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Also approved by Und. Lab. for L. P. G.

ROCKWOOD *FULL-FLOW* BALL VALVES

THE FLOW IS AS ROUND AS THE PIPE ITSELF

Licked before they start!

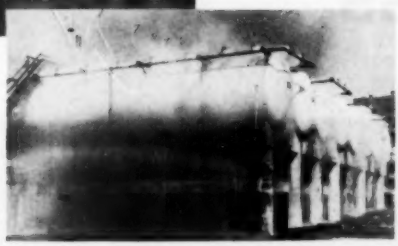
BLAW-KNOX FOG SYSTEMS DON'T GIVE FIRES A CHANCE TO GROW UP

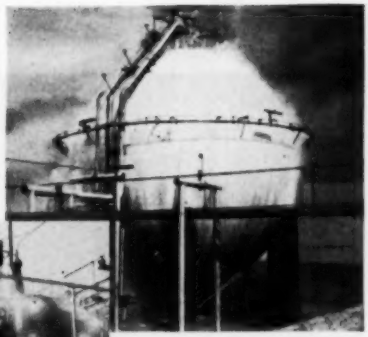
Chemical and petroleum fires strike fast with little or no warning. But not so fast that a Blaw-Knox Fog System actuated by rate-of-rise thermostats can't knock 'em out with a smothering blanket of fog *before* they really get started.

A Blaw-Knox System engineered for the fire hazards existing in or around your plant is a most effective weapon against fire's toll. On the job 24 hours a day, it protects your property as well as products essential to our national economy.

Glad to consult with you and submit an estimate without obligation.

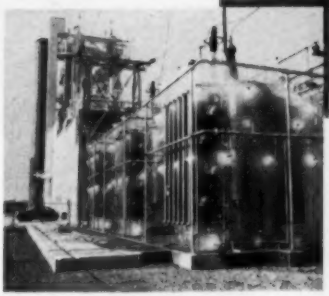
BLAW-KNOX CONSTRUCTION COMPANY
BLAW-KNOX SPRINKLER DIVISION
829 Beaver Ave., N.S., Pittsburgh 33, Pa.

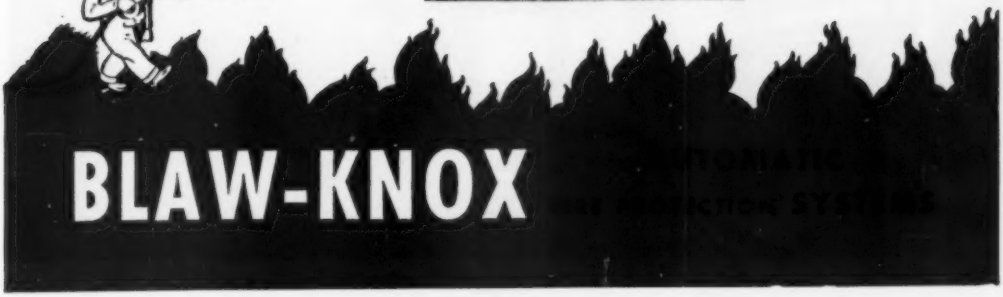




Deluge Systems, Wet Pipe Systems, Dry Pipe Systems, Water Spray and Fog Systems, Rate-of-Rise Sprinkler Systems, and Foam and Carbon Dioxide Extinguisher Systems.

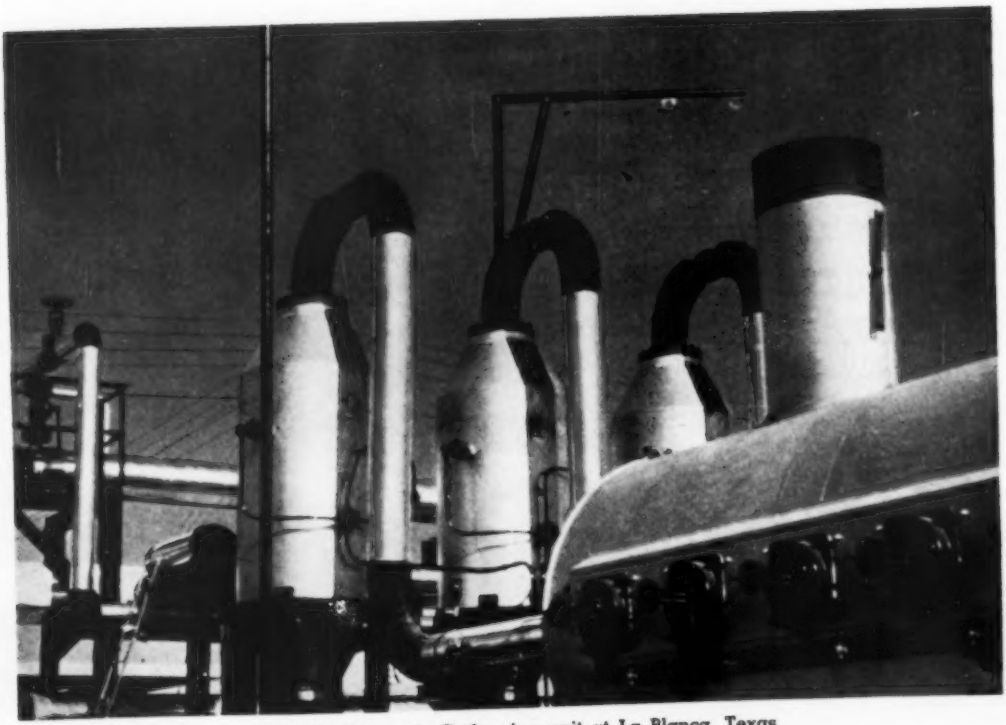
"LITTLE JOEY SPRINKLER"
Always on the Job



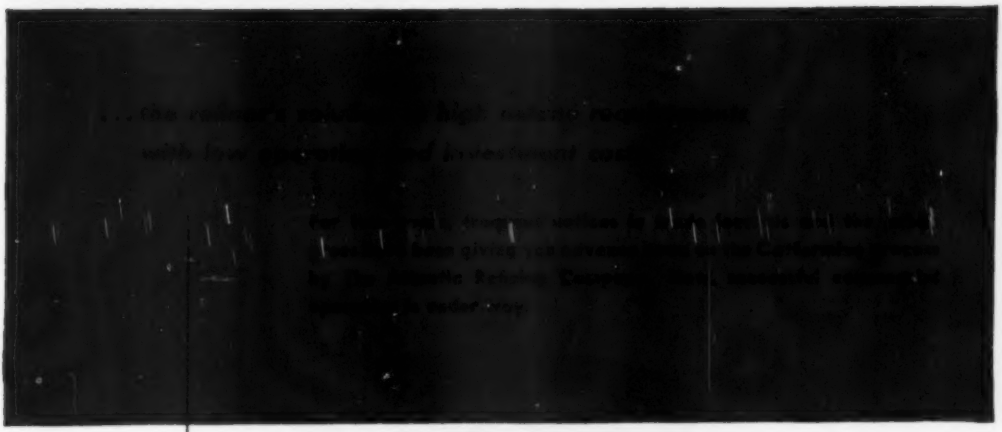


CATFORMING...

the Atlantic catalytic reforming process



McBride Refining's Catforming unit at La Blanca, Texas



it's the catalyst that counts

Since catalytic reforming was first utilized, numerous processes have been introduced to increase its benefits. None of these completely satisfied our requirements. So we looked for the answer in the catalyst itself.

years of research

Years of continuous laboratory study were devoted to the problem . . . in a search for a new catalyst with superior qualities. This extensive research paid off in a completely new catalyst which is the heart of Catforming. This catalyst combines improved selectivity, greater stability, excellent resistance to poisoning, and ease of regeneration.

now in commercial operation

Catforming is now in successful commercial operation. It is giving exceptional results. Our engineers are ready to give you the whole story. Call or write The Atlantic Refining Company, Research and Development Dept., P. O. Box 8138, Philadelphia 1, Pa. (Telephone, HOward 5-2345).

ATLANTIC

hot liquids

corrosives

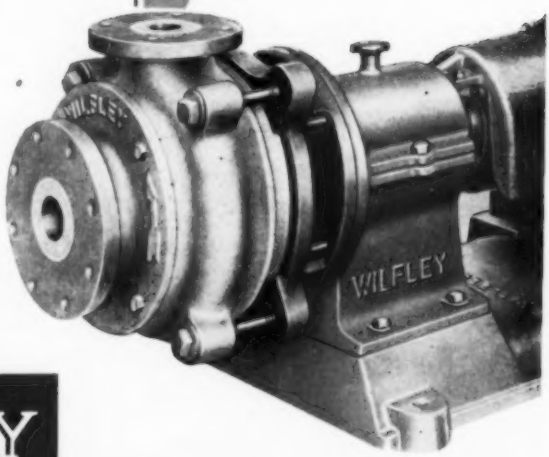
acids

Buy **WILFLEY** *for cost saving performance*

Companion to the famous **WILFLEY** *Sand Pump*

• For more efficient performance...greater economy of operation...specify **WILFLEY** "AF Acid Pumps. Dependable, trouble-free operation, on a round-the-clock schedule, with consequent stepped-up production and worthwhile power savings, are big reasons why modern chemical and processing plants all over the world now rely on **WILFLEY** Acid Pumps for handling acids, corrosives, hot liquids and mild abrasives.

• Available in 10- to 2,000-G.P.M. capacities, 15- to 150-ft. heads and higher. Wetted parts of practically all machineable alloys. Plastic lined models available. Every application individually engineered. Write or wire for details.



WILFLEY *Acid* **PUMPS**

A. R. WILFLEY & SONS, Inc., Denver, Colorado, U.S.A.

New York Office: 1775 Broadway • New York City

ATTAPULGUS Fullers Earth
POROCEL Activated Bauxites

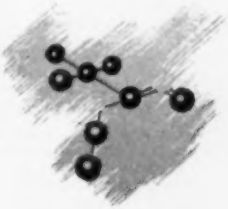
...two reliable names along the path of petroleum processing

WHAT DO YOU WANT TO PURIFY?

There's an Attapulgus or Porocel adsorbent to fit your process technique for removing odors, colors, tastes, moisture, acids, sulfur, fluorides and unsaturates from process liquids or gases. Materials treated in principal applications are: motor oils and other lubricating, specialty, and technical oils; petrolatums and waxes; aviation and motor gasoline stocks; kerosene; diesel and heating oils.

DO YOU HAVE CATALYST OR CATALYST CARRIER NEEDS?

Attapulgus or Porocel sorptive minerals are recognized standards in desulfurization, reforming and isomerization systems—catalytic removal of unsaturates—conversion of sulfides to elemental sulfur—fluid catalyst applications—as catalyst carrier in copper sweetening processes.



WHAT DO YOU WANT TO DRY?

We offer a wide range of reliable, thoroughly proved desiccants for drying air, hydrogen, carbon dioxide, hydrocarbon liquids and gases.

SPECIAL GRADES?

Mine and plant facilities permit prompt and economical production of grades meeting individual customer specifications. Our laboratories and technical staffs welcome the opportunity of assisting in research, development, design and operating problems. Your inquiries are invited.

ATTAPULGUS CLAY COMPANY *Fullers Earth* · **POROCEL CORPORATION** *Activated Bauxites*

Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

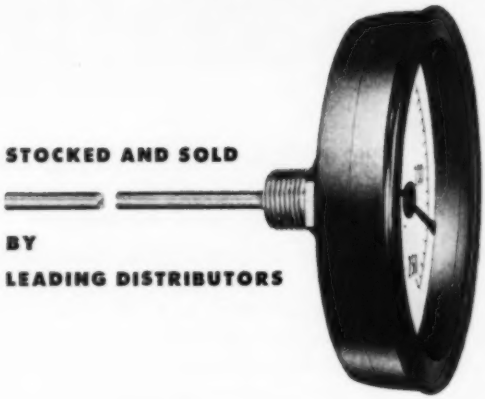
FOR EASY-TO-READ "ON THE SPOT" TEMPERATURE INDICATION, CHOOSE

Accurate AMERICAN BI-METAL DIAL THERMOMETERS

STOCKED AND SOLD

BY

LEADING DISTRIBUTORS



SPECIFIC NEEDS of refinery, chemical, power and other plants are met completely by American Bi-Metal Dial Thermometer. It makes accurate "on the spot" temperature readings easy *even from a distance.* It can be used where other types are not nearly so practical — and to avoid the higher cost of a distant reading thermometer. Installation is simple, fast and economical — only a ½" or ¾" N.P.T. tapped hole is required.

The fixed stem contains the highly sensitive bi-metal element. Accuracy of the instrument is guaranteed within 1% of the scale range. In extensive laboratory and field tests, sudden hot blasts, submersion, severe mechanical and thermal shocks, hot gases, dust and long exposure to the elements could not impair its accuracy or destroy the hermetic seal of the case.

Solve your "on the spot" temperature reading problems with rugged, accurate American Bi-Metal Thermometers. Two dial sizes, seven stem lengths, a wide range of temperatures, and the availability of separable sockets make selection easy. Get all the facts. Write for Bulletin 144.

SPECIFICATION DATA

Temperature Ranges: from minus 60° to 120° F., 200° to 1000° F. **Dial Sizes:** 3½" and 5". Graduations over full 270° arc. **Bezel:** Screwed to case. **Front:** Heavy plate glass set in channelled gasket — hermetically seals the case. **Pointer:** Adjustable type attached with set screw; easy to get at for setting. **Stem:** Stainless steel, ¼" diameter — lengths from 2½" to 24". Stem and connections welded — strong, corrosion resistant, leak-proof. **Connection:** Fixed, ½" N.P.T.

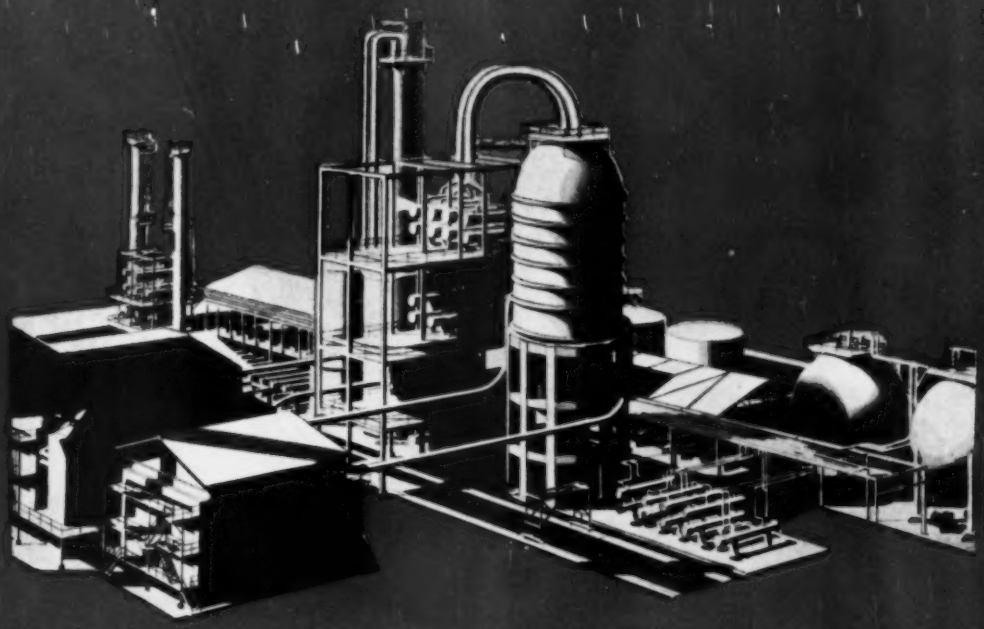
Separable Sockets available for use on closed systems or where the measured medium is corrosive to the stainless steel stem. Fit over all standard stem lengths except 2½".

AMERICAN INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, BUILDERS OF 'SHAW-BOX' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

crude distillation units



125,000 bbls/day

The unit illustrated above is an artist's drawing of probably the largest two-stage crude distillation unit in the world, now being designed and constructed by Foster Wheeler for the Gulf Oil Corporation at the Girard Point, Philadelphia refinery . . .

. . . but, whether 125,000 bbls/day, 25,000 or 1000 bbls/day FW know-how is at work for the refiner —as it has been for over 30 years—designing, fabricating and constructing more than 600 processing units of all types and capacities.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

FW

...today's dollar and tomorrow's returns

Here at Lummus we hold a deep respect for our customers' 1952 dollar and 1957 returns. *This* has a meaning all its own to responsible management with capital to commit for petroleum, petroleum chemical and chemical plants.

You'll find these price-and-value factors well taken care of in every project designed, engineered and constructed by Lummus. On each job, *process improvement* is the paramount goal—achieved by applying every technological advancement and modern design. This we won't compromise, no matter how great the demand may be for immediate new production facilities.

What's more, the plants must have the flexibility to answer needs of the future. Engineering ingenuity at Lummus concerns itself with taking every precaution today against a future time when outmoded tools may put you at a competitive disadvantage.

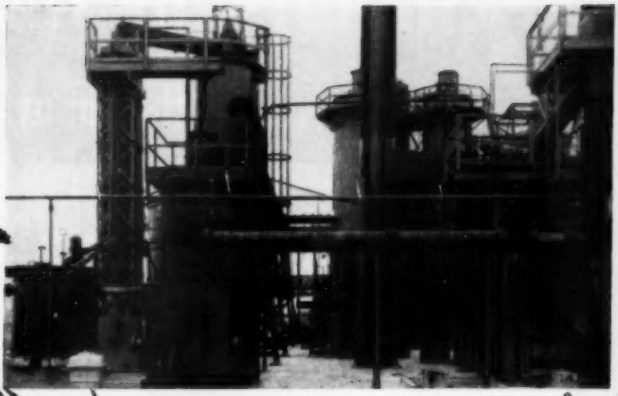
That sums up our interpretation of judicious spending. Over six **hundred** soundly-designed, profit-producing plants have been built on this steadfast concept. You may wish to bear these facts in mind on *your* next project.

THE LUMMUS COMPANY

385 MADISON AVENUE, NEW YORK 17, N. Y.

HOUSTON • CHICAGO • LONDON • PARIS • CARACAS

DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES



"Outlaw" becomes citizen

There may be an "outlaw," known as "refinery waste," in your plant. He may be robbing you of income through the loss of useful products. He may be costing you money in the expense of disposal. Perhaps he is stealing your community good will by stream and air pollution. If you have such "outlaw," reform him with a Monsanto-Ross-Wilde sludge-recovery unit.

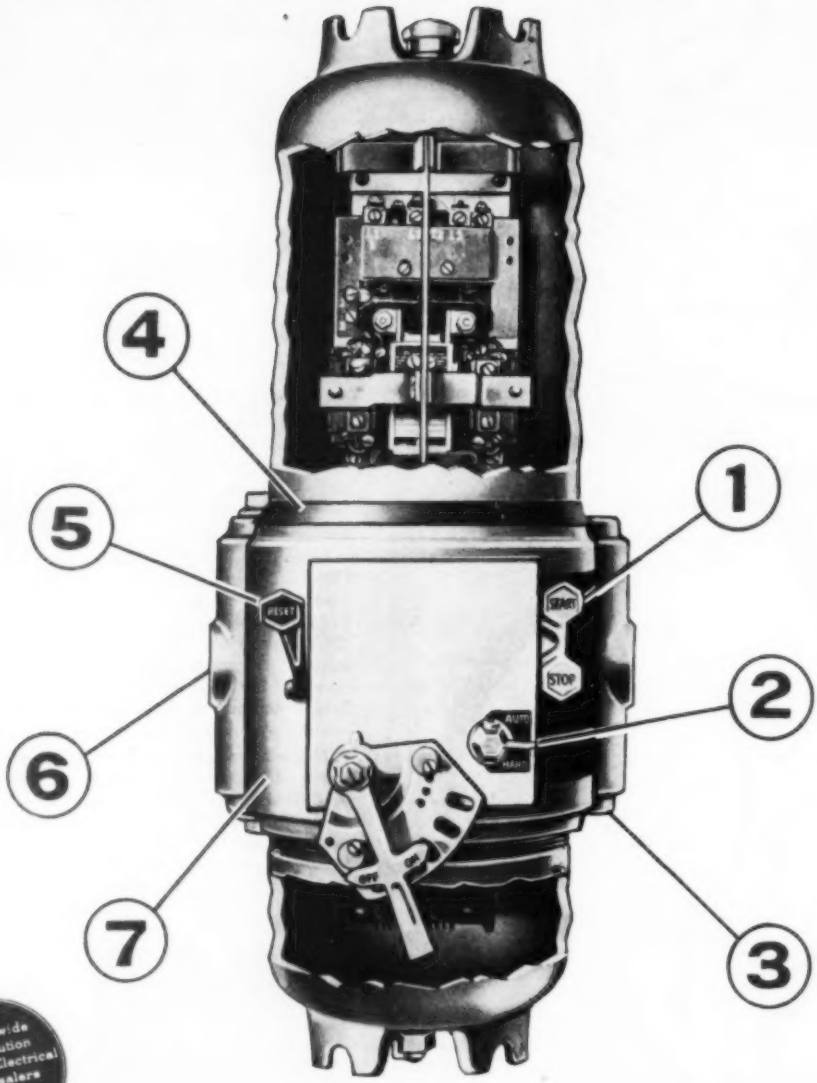
A Monsanto-Ross-Wilde unit will produce clean, high-strength SO_2 from sludge acid. Clean, white sulfuric acid can be produced from this SO_2 with or without the addition of SO_2 from the burning of H_2S or elemental sulfur. You can have the unit tied in with your sulfuric acid plant, or, Monsanto will furnish designs for sludge-recovery and sulfuric-acid units as one project.

A Monsanto representative will be glad to call to discuss technical features of the M-R-W unit and assist you in an economic study if desired. His services will cost you nothing and will not obligate you in any way. Write, wire or phone MONSANTO CHEMICAL COMPANY, Engineering Sales Department, 800 North Twelfth Blvd., St. Louis 1, Mo.

MONSANTO
CHEMICALS — PLASTICS
SERVING INDUSTRY ... WHICH SERVES MANKIND

7 important NEW features

... to the many basic advantages of



A Nationwide Distribution Through Electrical Wholesalers

CONDULETS • TRAFFIC SIGNALS

have been added

CROUSE-HINDS Type EPC

motor starter and circuit breaker CONDULET *

You get all of them on the Model M52

Model M52 EPC is the most flexible explosion-proof line starter and circuit breaker enclosure ever produced. The addition of 7 new features to the proven basic advantages of the EPC construction assures the greatest ease of installation and maintenance.

The exclusive basic advantages of the EPC Condulet have made it the world's leading enclosure for housing motor starters, circuit breakers and combinations for use in hazardous locations.

The basic advantages are:

EASY INSTALLATION . . . The use of a strong light-weight aluminum alloy and the unique three-section design makes it practical for an electrician and his helper to install the largest housing without the use of costly lifting equipment. The internal devices can be easily removed for pulling in the wires.

THREADED JOINT CONSTRUCTION . . . All joints are threaded. All operating shafts and bushings are thread-in-thread construction. This insures maximum safety, easy inspection and maintenance, and maximum corrosion protection.

FLEXIBILITY . . . A large number of different enclosures can be assembled from the wide variety of sizes of bodies and covers. They are not only used for circuit breakers and starters but have proven adaptable for many other types of electrical equipment. The body has numerous conduit hubs for flexibility of installation.

COST AND TIME SAVINGS . . . The outstanding advantages of the unique EPC Condulet over conventional explosion-proof enclosures all add up to lower installed cost and lower maintenance cost.

All of these advantages have been available for years.

Now Crouse-Hinds offers you 7 new improvements to underline the basic advantages of type EPC Condulets and to save you more dollars and more man-hours than ever before.

1. **Built-in Push button stations** available on line starters and combinations of line starters with circuit breakers — START — STOP, FOR — REV — STOP and HIGH — LOW — STOP stations for regular, reversing, or two-speed starters.
2. **Built-in selector switch** is available on line starters and combinations of line starters with circuit breakers. Normally supplied marked HAND — OFF — AUTO or JOG — RUN — OFF, three-position style. Two-position selector switch or combinations of selector switch with START — STOP station can be supplied.
3. **Back conduit entrance** can be supplied by drilling and tapping the boss in the center of the back . . . in addition to the four regular top and bottom hubs.
4. **Protective Neoprene gasket** is available for the upper cover joint. Where EPC Condulets are exposed to unusually severe weather or corrosive conditions, this gasket provides additional protection.
5. **A new RESET lever with threaded shaft,** rotating within a threaded bushing, provides easier and more positive operation of the reset mechanism.
6. **Horizontal through-feed conduit entrances** are provided by drilling and tapping bosses on the sides of the Condulet body.
7. **Greater ease in wiring** is provided by increased height in the center body section and by universal use of open framework mountings for circuit breakers and starters in the new model M52 EPC Condulets.

Model M52
Type EPC Explosion-Proof Condulet in 7, 9, and 11-inch body sizes

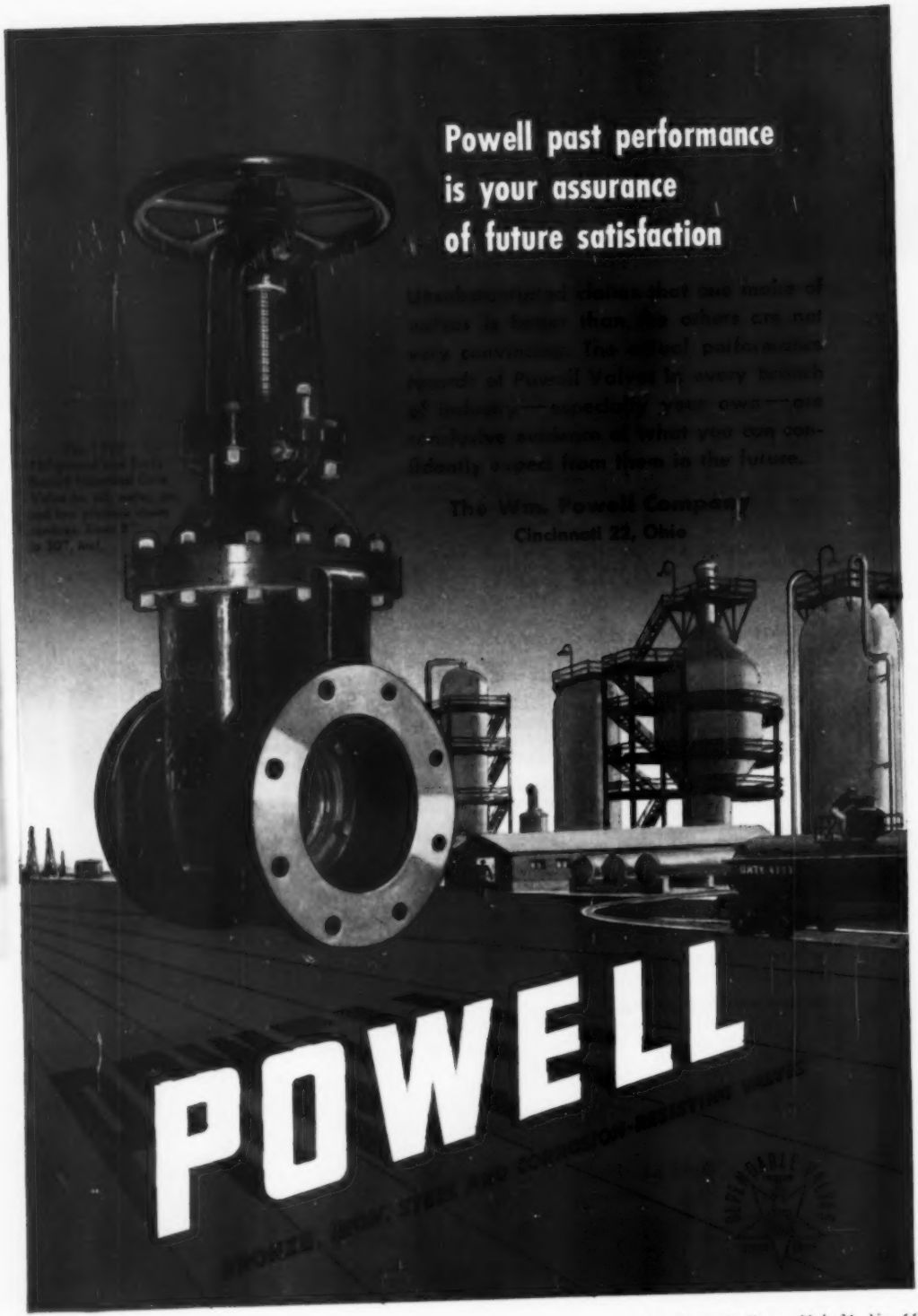
Send for YOUR copy of Bulletin 2634 →

* CONDULET is a coined word registered in the U. S. Patent Office. It designates a product made only by the Crouse-Hinds Company.

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

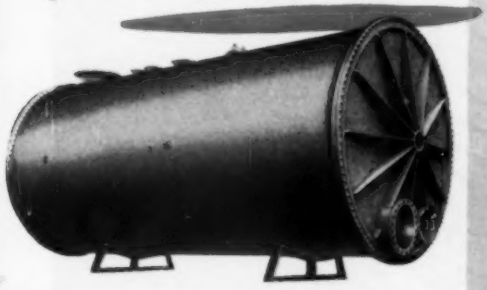
OFFICES: Albuquerque – Birmingham – Boston – Buffalo – Chicago – Cincinnati – Cleveland – Dallas – Denver – Detroit – Houston – Indianapolis – Kansas City – Los Angeles – Milwaukee – Minneapolis – New York – Philadelphia – Pittsburgh – Portland, Ore. – San Francisco – Seattle – St. Louis – Tulsa – Washington. RESIDENT REPRESENTATIVES: Albany – Atlanta – Baltimore – Charlotte – New Orleans – Richmond, Va. Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

AIRPORT LIGHTING • FLOODLIGHTS


Powell past performance
is your assurance
of future satisfaction
The Wm. Powell Company
Cincinnati 22, Ohio
POWELL

Outstanding IN Sulphur Recovery WASTE HEAT APPLICATION!

Titusville



Boiler above has 3500 sq. ft. heating surface. Design pressure 150 PSIG. Combustion area 6 PSIG. Process and combustion gases as fired: 22,000 lbs. per hour. Combustion gas temp. 2930°F.—exit temp. 530°F. Diameter of unit 114". Length over nozzles 24'3¼".

USED BY SUCH COMPANIES AS

Phillips Chemical Co.	Sinclair Refining Company
Gulf Oil Corporation	Consolidated Chemical Industries
Shell Chemical Corp.	Hancock Chemical Company

—and others

WASTE HEAT BOILERS

TITUSVILLE Waste Heat Boilers have been used with marked success for years in connection with sulphur recovery, and are in service or process of installation for most of the major oil producers and refiners in America.

Of basic Scotch Marine design, these units are fitted with special front and rear combustion chambers, and are sealed against pressure in the combustion area. The delivery picture is good: your order can be shipped within a comparatively short time, utilizing units in stock—in fabrication, or built from stock material.

THE TITUSVILLE IRON WORKS COMPANY

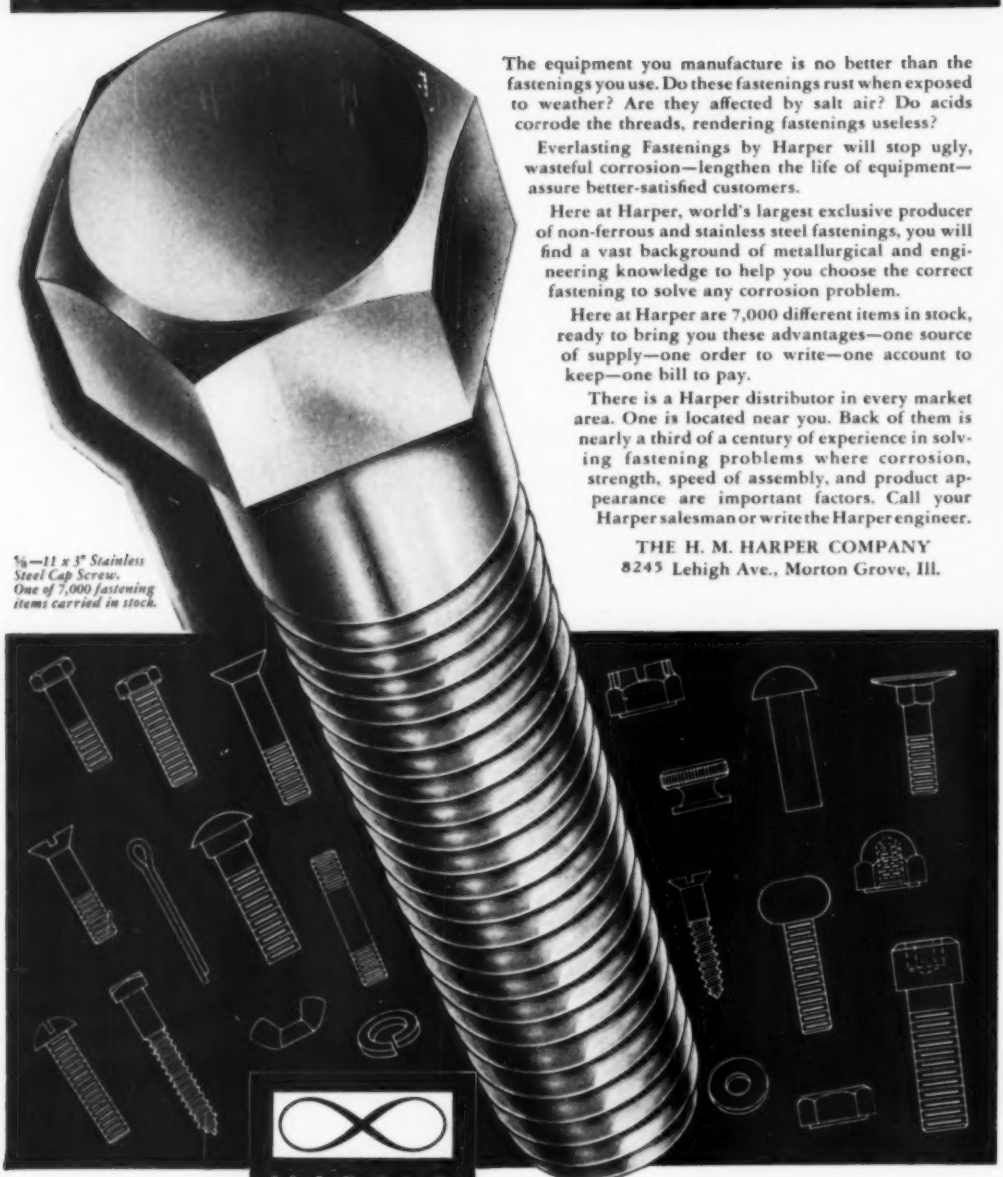
Division of Struthers Wells Corporation

TITUSVILLE, PENNA.

TITUSVILLE IRON WORKS CO TITUSVILLE, PA.

Struthers Wells

TROUBLE GOES OUT when HARPER FASTENINGS GO IN



⅜—11 x 3" Stainless Steel Cap Screw. One of 7,000 fastening items carried in stock.

The equipment you manufacture is no better than the fastenings you use. Do these fastenings rust when exposed to weather? Are they affected by salt air? Do acids corrode the threads, rendering fastenings useless?

Everlasting Fastenings by Harper will stop ugly, wasteful corrosion—lengthen the life of equipment—assure better-satisfied customers.

Here at Harper, world's largest exclusive producer of non-ferrous and stainless steel fastenings, you will find a vast background of metallurgical and engineering knowledge to help you choose the correct fastening to solve any corrosion problem.

Here at Harper are 7,000 different items in stock, ready to bring you these advantages—one source of supply—one order to write—one account to keep—one bill to pay.

There is a Harper distributor in every market area. One is located near you. Back of them is nearly a third of a century of experience in solving fastening problems where corrosion, strength, speed of assembly, and product appearance are important factors. Call your Harper salesman or write the Harper engineer.

THE H. M. HARPER COMPANY
8245 Lehigh Ave., Morton Grove, Ill.

HARPER

EVERLASTING FASTENINGS

SPECIALISTS IN ALL NON-CORROSIVE METALS

BRASS • SILICON BRONZE • NAVAL BRONZE • MONEL • ALUMINUM • STAINLESS STEEL

Something you may not have noticed about the S.S. United States

You've probably read all about the amazing construction, the great size and the record-breaking speed of the liner United States.

But you may not have noticed something extremely important about her crew. Every officer or man in a post of responsibility is a man of impressive experience. Her present skipper has been a ship master for thirty-two years. The chief engineer has been in engine rooms for 29 years. Even her executive chef has been in charge of ships' kitchens for 25 years.

In an operation as complex as sailing a great liner . . . or serving a great industry . . . there is simply no substitute for experience. And it is interesting to note that most of the men at the helm of the company which supplies the petroleum industry with the major part of its antiknock compound requirements are men who have been with Ethyl for upwards of twenty years.

(*Continued on next page*)

ETHYL
ETHYL CORPORATION

Printed in U.S.A.

Something you may not have noticed about the S.S. United States

(*Continued from preceding page*)

For example: The man in charge of manufacturing at Ethyl has been with us for 26 years. The head of technical services has had 23 years of Ethyl experience; the vice-president in charge of sales started with Ethyl 26 years ago; and all four regional sales managers have more than twenty-two years of service.

Is it any wonder that Ethyl appreciates and understands the problems of refining, distributing and selling petroleum products? So, whether the going is rough or smooth—and the oil industry has gone through plenty of stormy weather—you can rely on experienced Ethyl people to be on deck when you need them.

ETHYL CORPORATION
NEW YORK 17, NEW YORK

Ethyl service is backed by 29 years of antiknock experience

RESEARCH

SUPPLY SERVICE

TECHNICAL REPORTS

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PEERLESS TYPE PR

REFINERY AND CHEMICAL PROCESS PUMPS OFFER YOU ALL THESE FEATURES:

1. Center-line-mount design; heavy duty construction

2. Full range of sizes; many available from stock

3. Top suction or end suction, top discharge design

4. Designed particularly for pumping all hydrocarbons, water and numerous process liquids

5. Spacer type coupling to permit liquid end disassembly without disturbing piping

6. Oversize heavy duty heat treated alloy steel shaft

7. Oil lubricated, heavy duty radial & thrust bearings

8. Spot electric welded case- and impeller-wear rings

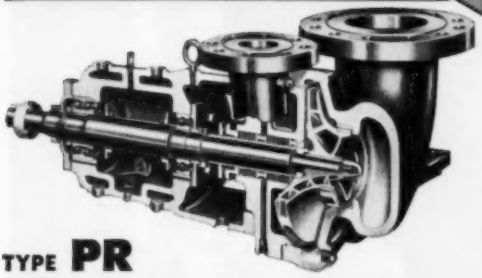
9. Capacity range: up to 1000 GPM

10. Operating heads: up to 625 feet; case pressures: to 400 PSIG

11. All types of drive; electric, steam turbine, stationary engine

12. Designed to operate with minimum NPSH

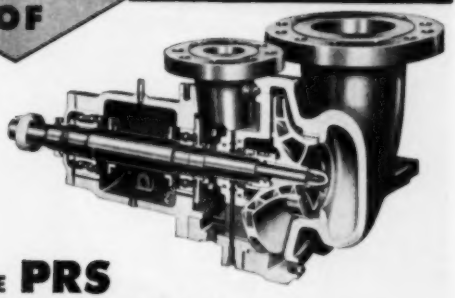
PACKING GLAND CONSTRUCTION *plus* THE CHOICE OF MECHANICAL SHAFT SEAL



TYPE **PR**

IMPROVED PACKING GLAND CONSTRUCTION

RECOMMENDED FOR TEMPERATURES TO 850° F.



TYPE **PRS**

DESIGNED FOR & WITH A SHAFT SEAL

RECOMMENDED FOR TEMPERATURES TO 250° F.

Select your pumps from these two proved Peerless designs built especially for refinery and process service. Remember: the Type PRS shaft sealed pump is designed with and for a mechanical shaft seal, not just adapted to it. Send coupon today for descriptive Type PR pump bulletin.

PEERLESS PUMPS

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
301 West Avenue 26, Los Angeles 31, California

Please send us a Bulletin on Type PR and PRS pumps

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

PR

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION

Factories: Indianapolis 8, Indiana and Los Angeles 31, California
Offices: New York; Chicago; Indianapolis; Atlanta; St. Louis; Dallas, Lubbock and Plainview, Texas; Tulsa; Albuquerque; Phoenix; Fresno; Los Angeles.
Distributors in Principal Cities. Consult your Telephone Directory.

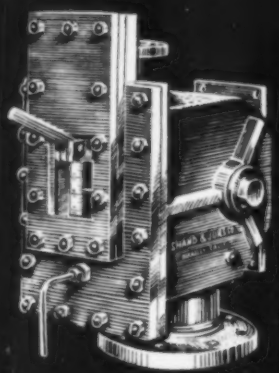
fmc FOOD MACHINERY AND CHEMICAL CORPORATION

TWO ACES

There's no gambling when you use either of these two Shand & Jurs High Pressure Automatic Tank Gages. Both are designed to produce economical tank gaging, precise measurement, dependability and long useful life. S. & J. Fig. ST-400 Automatic Tank Gage is designed for operating pressures up to 150 pounds, the ST-400P for pressures to 300 pounds. The stainless steel reading tape is completely enclosed and kept taut at all times by an internal counterweight. The tape is read through a window of heavy safety glass which is further protected by a steel safety closure which in normal position covers the glass.

S. & J. Fig. ST-400 type gage is also made for roof mounting in both pressure ranges. The S. & J. Tape Block Valve, ST-5265 can be employed with either gage to isolate the gage head from the tank vapors for purposes of inspection and maintenance.

No, there's no gambling when you use S. & J. High Pressure Automatic Tank Gages.



S&J

Shand and Jurs Co. 8TH AND CARLTON STREETS : BERKELEY : CALIFORNIA

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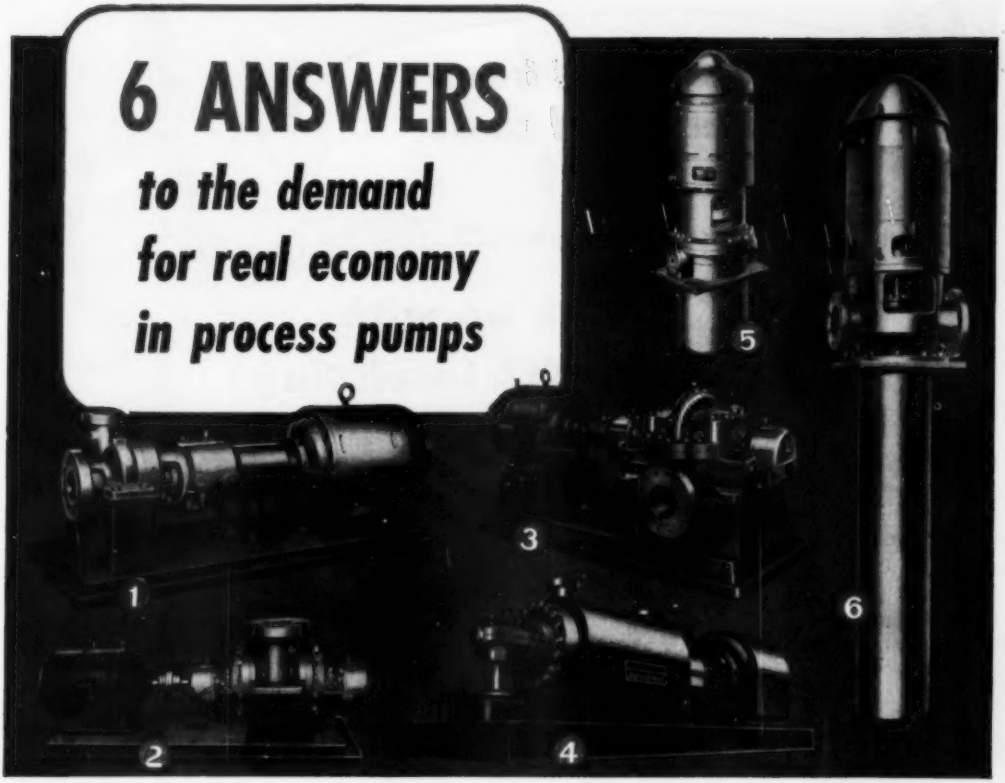

These six types of Ingersoll-Rand process pumps offer you important savings in most refinery jobs.

For most refinery and process plant applications, there's an Ingersoll-Rand pump that is right for the job. This means more than just meeting design conditions – it means construction of the *right* materials and the *right* sealing arrangement, with either the Cameron Shaft Seal or an adaptation of a packed stuffing box. These and other points of pump know-how can only be gained through years of field and design experience – experience which Ingersoll-Rand has had in over 50 years of service to the petroleum industry.

Let your nearest I-R representative give you the details on the real economy of I-R pumps – high sustained efficiency, economical operation, and low maintenance.

	PUMP TYPE	STAGES	CAPACITIES	HEAD
1	Vertically split with top (or bottom) suction and discharge or end suction and top discharge	Single stage	20 to 3200 gpm	Heads to 600 feet
2	Vertically split with top suction and discharge	Single stage	250 to 3500 gpm	Heads to 1100 feet
		Two stage	200 to 1200 gpm	Heads to 1100 feet
3	Horizontally split with side suction and discharge	Single stage	30 to 2300 gpm	Heads to 750 feet
		Two stage	170 to 1300 gpm	Heads to 1100 feet
4	Diffusor type with "double-case" construction. Top suction and discharge.	Multi stage	450 to 3000 gpm	Heads to 6000 feet
5	Vertical pump, diffusor type	Multi stage	20 to 400 gpm	Heads to 4800 feet
6	Vertical pump, turbine type	One or more stages	60 to 35,000 gpm	Heads to 150 feet per stage

Compressors • Air Tools • Rock Drills
Turbo Blowers • Condensers • Centrifugal Pumps
Diesel and Gas Engines

Ingersoll-Rand

11 Broadway, New York 4, N. Y.

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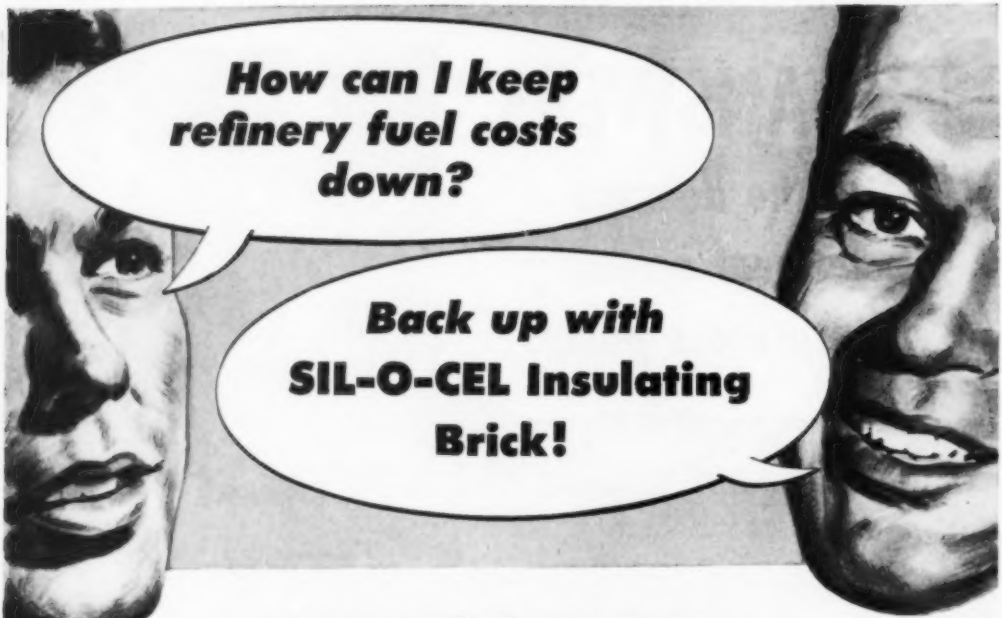
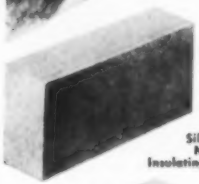
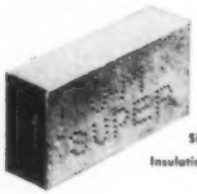


3 economical answers to high-temperature insulation problems


Sil-O-Cel Natural Insulating Brick

Sil-O-Cel C-22 Insulating Brick


Sil-O-Cel Super Insulating Brick

NATURE HERSELF has produced one of the most effective high-temperature insulating materials ever discovered—diatomaceous silica, from which Sil-O-Cel® Insulating Brick are made.

These insulating brick are used for back-up insulation behind fire brick or insulating fire brick linings in boilers, stills, stacks, reactor chambers, regenerators, heaters, flues, retorts, and other types of high-temperature equipment.

Sil-O-Cel Insulating Brick have excellent insulating qualities combined with high load-bearing characteristics and light weight.

Made in all standard shapes of the 2½ in. and 3 in. series, Sil-O-Cel Insulating Brick are produced in three basic types:

SIL-O-CEL NATURAL INSULATING BRICK
for temperatures to 1600F

Quarried directly from one of the world's purest deposits of diatomaceous silica, these insulating brick have a conductivity of only 0.79 Btu in./sq ft/F/hr at 1000F mean temperature, with heat flow perpendicular to brick strata. Yet their density is only 30 lb/cu ft. Cold crushing strength, 400 psi.

SIL-O-CEL C-22 INSULATING BRICK
for temperatures to 2000F

Ideal where high load-bearing properties are needed, this type of Sil-O-Cel is calcined, and has a cold crushing strength of 700 psi. Conductivity is 1.88 Btu in./sq ft/F/hr at 1000F mean temperature. Density, 38 lb/cu ft.

SIL-O-CEL SUPER INSULATING BRICK
for temperatures to 2500F

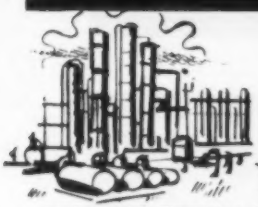
A calcined insulating brick for unusually high temperatures. In many cases, it is also possible to save on construction costs by reducing the thickness of fire brick or insulating fire brick when backed with Sil-O-Cel Super Insulating Brick. Conductivity is 1.95 Btu in./sq ft/F/hr at 1000F mean temperature. Density, 40 lb./cu. ft. Cold crushing strength, 300 psi.

For further information, write to Johns-Manville, Box **60**, New York, N. Y. In Canada, write 199 Bay St., Toronto 1, Ont.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** *first in* **INSULATIONS**

BEAIRD

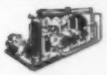
CAST STEEL FITTINGS



YOU CAN EASILY RECOGNIZE THE BEAIRD FITTINGS IN ANY INSTALLATION. You notice the finished look of the flanges, the complete backfacing and machining of flange edges, the true alignment of gasket surfaces and the uniform spacing of bolt holes. These features are the result of two decades devoted to producing a cast steel fitting of unmatched quality.

Ask your supply house for Beaird cast steel fittings — or write to us direct for a quotation on your requirements.

THE J. B. BEAIRD COMPANY, INC. **SHREVEPORT, LOUISIANA**


PACKAGED COMPRESSOR PLANTS

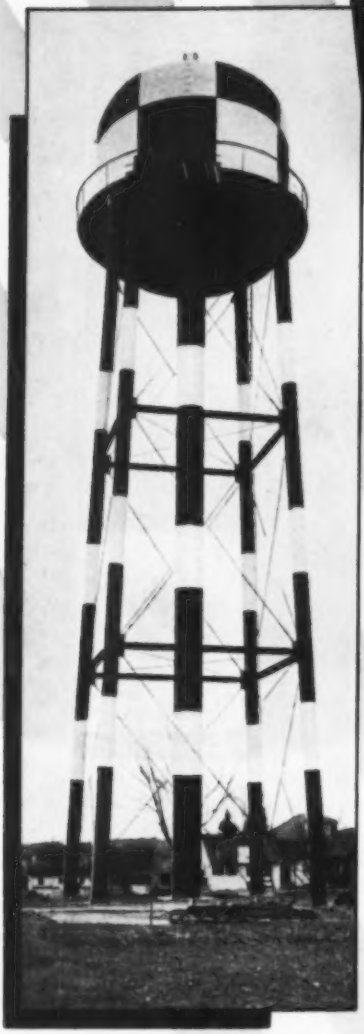
L.P. GAS SYSTEMS

ANHYDROUS AMMONIA EQUIPMENT

PRESSURE BULK STORAGE

MACHINING
FABRICATING
STEEL WAREHOUSE

Here's a Steel Plate Fabricator Who Talks The OIL MAN'S LANGUAGE



For a long time . . . and on a wide range of steel plate construction and erection jobs . . . Posey Iron has been "talking it over" with oil men. Practical, work-a-day experience with refinery and oil field installations has acquainted Posey Iron engineers with "the facts of life" in the oil business.

You'll find we understand peak loads . . . pressures . . . reserve capacities . . . fire protection requirements . . . alloys . . . welding practice . . . and specialized construction *as they apply to the oil field*. Every Posey Iron tank is fabricated with an ample safety factor . . . and to meet standard codes.

The Posey Iron Work's plant (16½ acres under roof) has complete facilities for machining . . . x-raying . . . pickling and painting. A consultation with one of our engineers may result in economies in your steel plate fabrication work.

View of 200,000 gallon tank with ellipsoidal bottom designed, fabricated and erected by the Posey Iron Works

Alloy Steel Refinery Pipe awaiting shipment from Posey Iron's North Plant

Fractionating Column for high octane aviation gasoline 3' I.D. x 133' high

POSEY IRON WORKS, INC.

Steel Plate Division

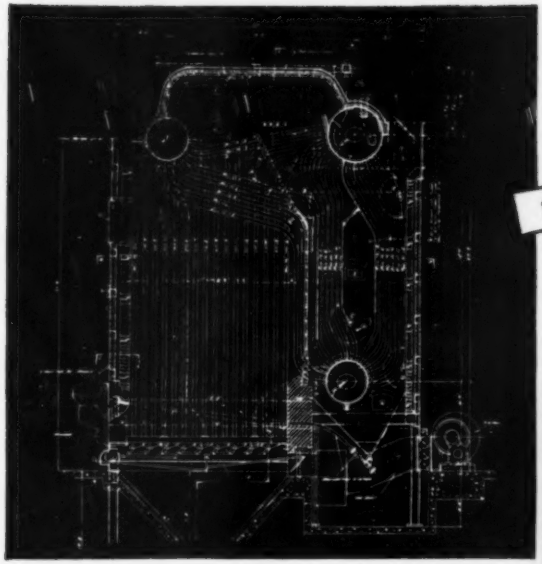
LANCASTER, PENNA.

New York Office: Graybar Building

ESTABLISHED SINCE 1910

DIVISIONS
Brick Machinery
Foundry
Industrial Heating
Inspection
Shipbuilding
Steel Plate

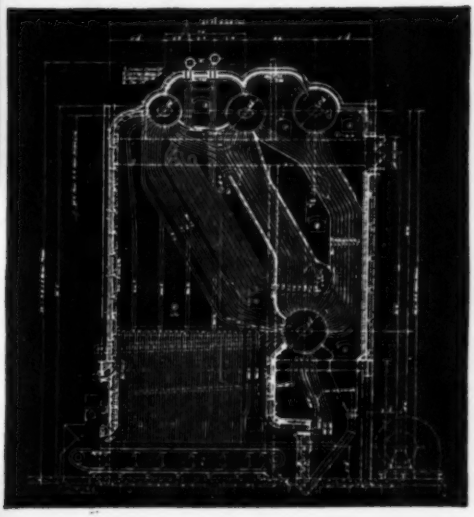
Quick Steaming at all Ratings!



Carry high overloads with high efficiency

SPECIFY Vogt

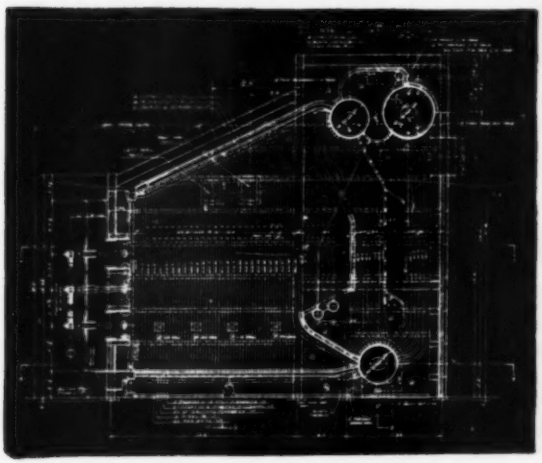
STEAM GENERATING UNITS



CLASS VL Two 27,500 pounds per hour units, installed at Brown-Forman Distillers Corporation, Louisville, Ky. Features large furnace volume in limited space, with high ratio of radiant heating surface.

CLASS LE Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnsue, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.



Vogt builds a complete line of bent tube steam generators, designed to burn solid, liquid, or gaseous fuels to meet specific operating conditions. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Bulletins with general information and showing typical installations are available upon request.

HENRY VOGT MACHINE CO.

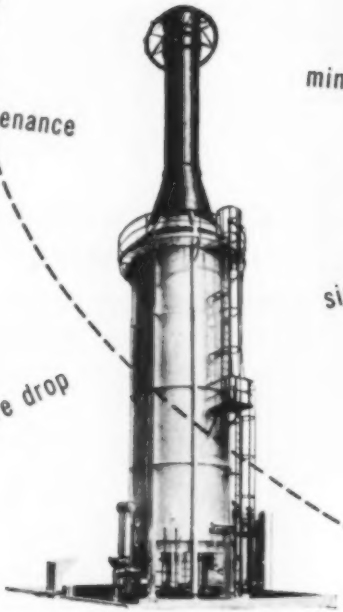
LOUISVILLE 10, KENTUCKY

BRANCH OFFICES:
NEW YORK, PHILADELPHIA, CLEVELAND
CHICAGO, ST. LOUIS, DALLAS

most efficient

PETRO - CHEM ISO - FLOW FURNACES

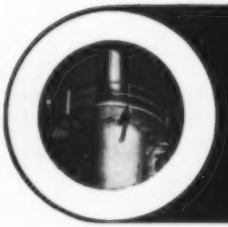
by any comparison



BETTER HEAT DISTRIBUTION...

maximum outlet temperature can only be obtained with uniform heat distribution and it's the uniform heat distribution characteristic, inherent in the design of Petro-Chem Iso-Flow Furnaces that permits optimum operating efficiency of gas cracking units . . . maximum production of catalytic cracking feed stocks . . . maximum yields of overhead products in vacuum operation.

More than 1000 are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petro-Chem Iso-Flow Furnaces are pre-eminently satisfactory.



PETRO-CHEM ISO-FLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INCORPORATED

122 EAST 42ND STREET, NEW YORK 17, N. Y.

Representatives: Bethlehem Supply, Tulsa and Houston · Flagg, Brackett & Durgin, Boston · D. D. Foster, Pittsburgh · Faville-Levally, Chicago · Lester Oberholtz, California · Gordon D. Hardin, Louisville, Kentucky

SECOND NATURE . . . FIRST CHOICE

Domestic or foreign, BS&B's contract fabricated jobs find their way to the important oil & gas centers. On the truck is an absorber column ready for delivery to West Texas. Lower picture shows a stabilizer feed surge drum loaded on flat car and ready to leave BS&B's Oklahoma City plant for shipment to Central America.

The industry looks to BS&B for *Contract Fabrication*

Second nature for the industry because of BS&B's reputation in contract fabrication; Second nature for BS&B because of our years of experience with pressure vessels. Add them up and see why BS&B is the oil industry's first choice for contract fabrication.

Evidence of the great volume of BS&B custom and standard equipment is scattered throughout the far-flung oil patches of the world . . . towers within the orderly jungles of our fast growing refinery, chemical and petrochemical plants. BS&B has served the petroleum industry for 60 years.

BS&B is today's recognized leader in introducing the very latest standard equipment . . . but we don't stop here. At BS&B contract fabrication, too, is big business, very big business. Our "second nature" is constantly at work. BS&B's reputation and experience are sure ways for you to measure the satisfaction and performance you can expect, that can be yours, on your next contract fabrication job.

Had a look-in lately on our greatly expanded Oklahoma City plant? We're keeping these facilities very busy . . .

Submerger arc (automatic), metallic arc (manual), oxyacetylene, and inert-gas-shielded metal arc welding . . . Well equipped machine shop that can handle both ferrous and non-ferrous alloys, solid and clad materials . . . New 2000° stress relieving furnace . . . Quality control, inspection and testing equipment in constant use.

What are your requirements?

Even if your job weighs 150 tons we can handle it . . . and we can handle diameters from 16" through 13'-0" — plate thicknesses from 14 gauge through 5". Let BS&B's experienced and qualified engineers talk it over with you. Write . . .

Contract Sales Division — Dept. 5-F11

BLACK, SIVALLS & BRYSON, INC.

2131 Westwood Blvd. Oklahoma City, Oklahoma

EFFICIENCY BS&B RELIABILITY OUR 60TH YEAR

EXTRA THICKNESS* in critical areas . . .
LONGER LIFE for alloy piping systems
with KEY-KAST alloy steel welding fittings!

AVAILABLE IN ALL SHAPES . . . SIZES . . . SCHEDULES . . . IN LOW AND INTERMEDIATE ALLOYS AND VARIOUS STAINLESS STEELS.

Check these PLUS advantages of KEY-KAST welding fittings against your alloy fitting needs!

- Greater wall thickness throughout—for increased structural strength.
- Greater allowance against corrosion and erosion.
- Meets A.S.M.E., A.S.T.M. and A.S.A. codes.
- Lower unit cost.
- Bosses provided on all fittings for tapped openings.
- Controlled quality . . . through rigid metallurgical control . . . produced, inspected and tested in one plant.

WRITE TODAY for new Bulletin 494-E
Please make request on your letterhead.

key company

Since 1916 . . . manufacturers and developers of products for high temperatures and pressures

DISTRICT OFFICES: NEW YORK • CLEVELAND
CHICAGO • TULSA • HOUSTON • LOS ANGELES

TO

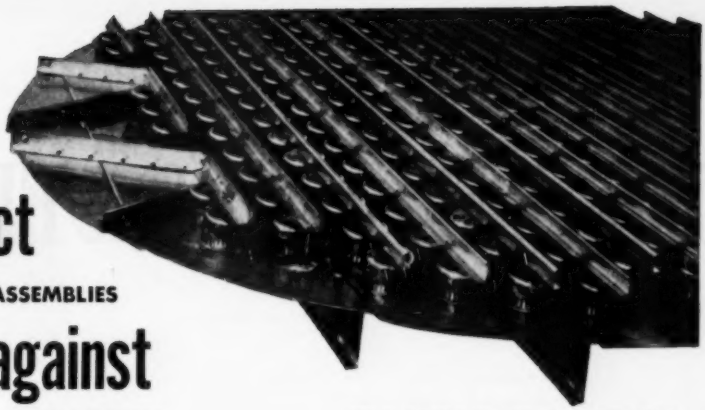
protect

YOUR CAP AND TRAY ASSEMBLIES

against

CORROSION

damage



Fritz W. Glitsch & Sons, Inc., Dallas, Texas, fabricated this lightweight bubble cap and tray assembly of corrosion-resisting Monel to withstand hydrochloric acid corrosion in the top section of a refinery fractionating tower. The strength and ductility of wrought Monel and Inconel lessen chances of breakage during installation. Trays which have been distorted by explosion can readily be straightened in the field.

There are two commercial non-ferrous metals that offer the protection your fractionating and distillation equipment needs.

Each gives you excellent corrosion resistance...*plus* high strength ...*plus* toughness...*plus* ductility.

Both metals are Inco nickel alloys – Monel and Inconel.

Their properties make it possible to use relatively thin-gauge metal for many applications. This means, of course, that you get lighter assemblies. Your cost for materials is lower...and installation and maintenance easier.

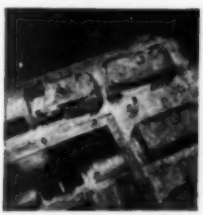
What governs your choice of Monel or Inconel? For the most part, it depends on service conditions.

Monel caps and trays are usually preferred where operating temperatures remain below 500°F. They are used to withstand the effects of dilute hydrochloric acid and wet sulfur types of corrosion in the upper sections of fractionating towers...and in the regeneration of spent caustic soda. Inconel, the nickel-chromium alloy, is used to resist high-temperature oxidation attack and naphthenic acids.

A wide range of designs is possible with Monel and Inconel. All are readily fabricated. They can be cut, formed, machined and welded by ordinary shop methods. They need no heat treatment after fabrication to develop maximum resistance to corrosion.

Keep Monel and Inconel in mind when you run into problems involving the use of metals in fractionation. And call on Inco's Technical Service for all the help you need. They have a world of information on hand, and are always glad to share it with you. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

Successful Experiment. Here you see the excellent condition of a Monel cap and tray assembly after extensive experimental service at the top of a caustic soda regenerator unit. Note how badly the adjacent steel wall has been corroded. In the same column, a steel tray with cast iron bubble caps ➧ was located directly beneath the all-Monel top assembly. Corrosion made visible progress on the lower assembly, while the top tray and caps easily withstood attack.

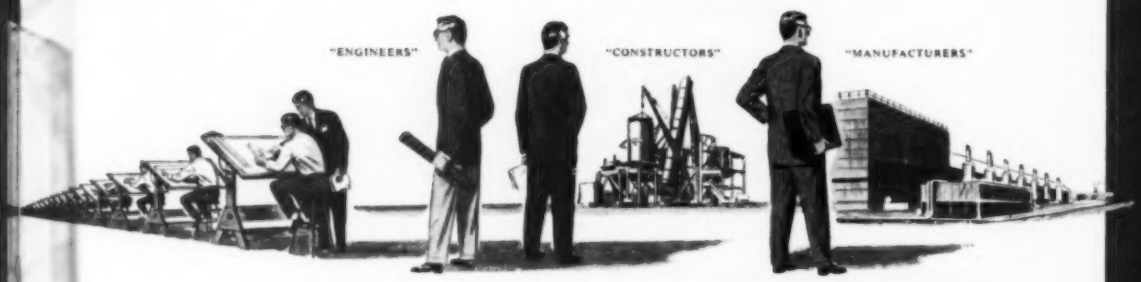


Because of defense needs, Inco Nickel Alloys are now on extended delivery. Orders should be placed well in advance, together with NPA rating and complete end-use information.

Inco Nickel
ALLOYS

Monel® • "R"® Monel • "K"® Monel
"KR"® Monel • "S"® Monel • Nickel
Low Carbon Nickel • Duranickel® • Inconel®
Inconel "X"® • Incoloy • Nimonics®

How would you define FLUOR?



Some say it's an Engineering Firm, others say it's a Construction Company. Still others call Fluor a Manufacturer. Actually Fluor is all three!

Because of the breadth of Fluor's activities since the turn of the century, different people in different industries have identified Fluor as an engineering firm, a construction company, or a manufacturer of cooling and processing equipment. This is understandable.

It is because, where clients have used Fluor's highly specialized services *individually*—engineering, construction *or* manufacturing—satisfaction itself has identified Fluor as an expert in the particular service successfully performed. This can be good. But it can also be limiting to the industries which Fluor serves.

It can be limiting in the sense that the satisfied client of a *single* Fluor service may, through incomplete identification, miss the benefits of Fluor's *complete* service—engineering, construction *and* manufactured products. Whenever you plan new construction or the expansion of old, compare *all* of Fluor's qualifications and services. The abilities to design, engineer and construct complete plants and facilities for the petroleum, chemical and other heavy industries—anywhere in the world—on time and within appropriation, have been proved time and time again.

These facts about Flour give the complete story of what Fluor does—what Fluor has to offer *you*. More detailed information may be obtained from your nearest Fluor representative. He will be pleased to cooperate in any way possible. You can be *sure* with Fluor!

These Facts make Fluor a World Wide Organization

A MANAGEMENT KNOWN FOR ITS EFFICIENT ORGANIZATION
—of Fluor—of your project within Fluor

The ability to organize in the face of constantly changing conditions accounts for Fluor's steady growth into recognition as a major engineering and construction firm. Good organization is demonstrated in the pride and teamwork evident throughout Fluor—in the handling of client's projects within Fluor. Each project has its own unit job organization under *one* project manager. He draws upon the many technical groups which make up Fluor and is responsible for your project—from beginning to completion.

A RESEARCH AND DEVELOPMENT DIVISION
for the study of problems—the development of ideas

Fluor's Research and Development Division is staffed with technically educated and thoroughly experienced chemical engineers, chemists, physicists, and mechanical engineers, specializing in fundamentals and problems relating to the gas and petroleum processing industries and phases of the petrochemical and chemical industries. These personnel and facilities are available at all times to Fluor's engineering groups for the study of unusual problems and development of new ideas.

A PURCHASING GROUP—AN ACCOUNTING GROUP—
wide in scope—flexible in operation.

These two highly specialized departments play a vital role in the successful and satisfactory completion of Fluor projects. They are geared to coordinate both inter-departmentally and with the established procedures of customer and vendor companies. Their services include the purchasing, inspection and expediting of materials and equipment for job sites anywhere in the world, and the establishment of efficient accounting systems according to individual client requirements. Broad experience is evidenced—material and equipment is being currently purchased at the rate of over $5,000,000 a month!

A LARGE RESERVOIR OF ENGINEERING TALENTS—
with broad, diversified experience—modern facilities

Fluor's Engineering Division is permanently staffed with over 800 chemical, process, mechanical, electrical, instrument, civil, architectural and hydraulic engineers and draftsmen. Headquartered in Los Angeles and Houston in modern buildings designed specifically for the expeditious handling of a large variety of engineering services, the broad and diversified experience of these groups embraces all types of projects—from the smallest unit to the largest—in natural gas, petroleum, petrochemical and industrial fields.

AN EXPERIENCED CONSTRUCTION ORGANIZATION—
skilled in all crafts—world-wide in reputation

Working in parallel and complementing the skills of Fluor's engineering groups, the Construction Division is permanently staffed with over 250 key men who are experienced in the construction of plants and facilities both in and out of the continental United States. This policy assures the availability of competent men for every project and enables Fluor to retain a closely knit organization which may be expanded around a nucleus built up over a period of years. The soundness of the policy is evident in the high degree of loyalty of these men to the interests of both Fluor and its clients.

A MANUFACTURED PRODUCTS DIVISION—
an independent division—complete within itself

Fluor's Manufactured Products Division is a large, completely integrated organization devoted exclusively to the design, development and manufacture of natural draft and induced draft cooling towers, air-cooled heat exchangers, pulsation dampeners, mufflers, gas cleaners, and other special products. This division functions independently, with modern facilities strategically located on the West Coast and in the center of the United States. The highly specialized products manufactured by this division are recognized throughout the world for sound engineering, quality construction and guaranteed performance.

STRATEGICALLY LOCATED SALES AND SERVICE OFFICES—
close client contact—the ability to serve

Fluor's Sales and Service offices are so located and so staffed that continuing sales and technical contact can be maintained to meet customer requirements anywhere in the world. Fluor representatives are technical men with technical experience. They are qualified to give detailed information—to make decisions. These things are important when evaluating the abilities of a contractor to successfully perform difficult and complex projects involving engineering, construction and/or the supplying of special products.

FLUOR

Engineers - Constructors - Manufacturers

THE FLUOR CORPORATION, LTD. • LOS ANGELES • HOUSTON
New York, Chicago, Pittsburgh, Boston, Tulsa, San Francisco, Birmingham and Calgary

Represented in the Sterling areas by:
Head Wrightson Processes Ltd., Teesdale House, Baltic Street, London, E.C.1, England

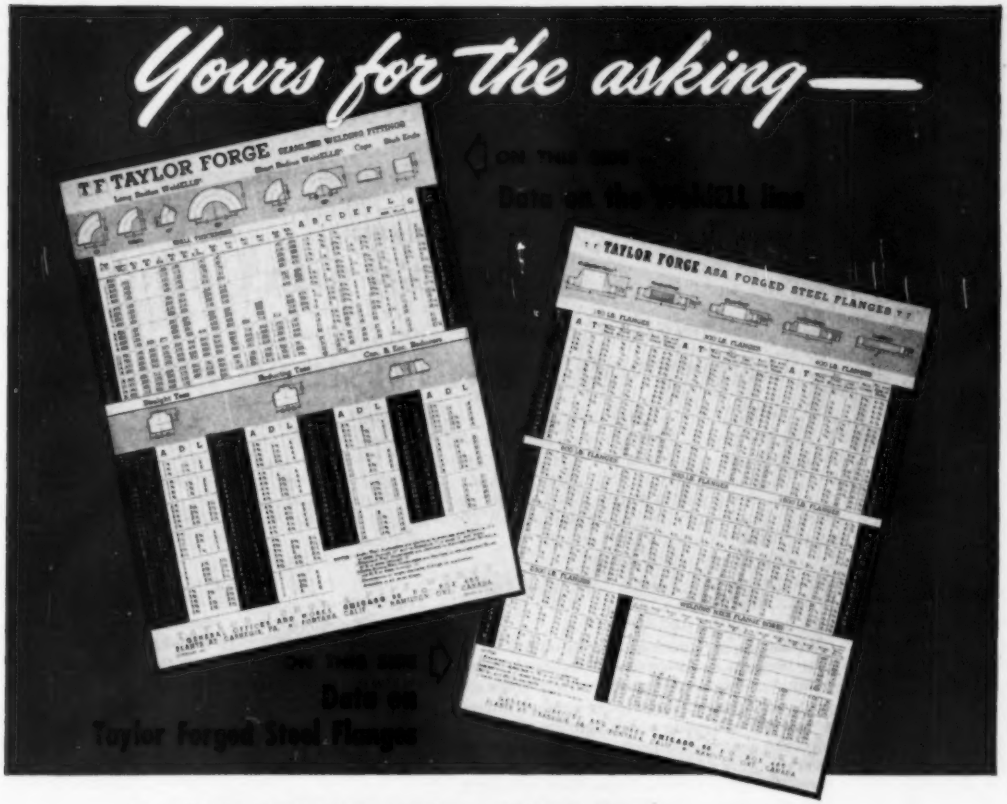
BE SAFE WITH FLUOR

The barrel that can't be emptied

Many a man can remember reading by kerosene lamp. For however fast time speeds by, it hasn't been very long since lamps played an important part in lighting the homes of the West and Standard was a small company proud of its ability to get from 5 to 10 gallons of its principal product, "coal oil," from a barrel of petroleum.

Count a few of the products made from oil today! Almost every item pictured above comes directly or indirectly from oil: (1) the enamel on stove, refrigerator and cabinets, (2) the dryer in the wall paint, (3) the plastic in the clock cover, curtains, apron, (4) the linoleum, (5) the drainboard covering at the sink, (6) the detergents used in washing—(7) the finish on the car and (8) the synthetic rubber of its tires. ¶ Add to these asphalt for paving and roofing, insecticides, cosmetics, dry cleaning solvents...and, of course, steadily improving gasolines and motor oils...and you begin to see how important oil has become. ¶ More than 1100 products are now being made from petroleum by Standard, and others are on the way. We have spent $35,000,000 in research and technical service in the last 5 years alone...to make a barrel of oil truly "a barrel that can't be emptied" in terms of the good things it contributes to your daily living.

STANDARD OIL COMPANY OF CALIFORNIA ***plans ahead to serve you better***



A VOLUME OF DATA

. . . covering welding fittings and forged steel flanges . . .

ON A SINGLE SHEET

Here is just about the handiest tool ever devised for the pipe designer. Data on welding fittings and flanges that otherwise could be found only by plowing through many catalog pages and tables have been ingeniously condensed on the two sides of the durable letter-size card illustrated above.

One side covers the broad WeldELL line of Taylor Forge welding fittings. For every nominal pipe size, ½" through 30", it shows the wall thickness for every weight of every fitting in every available material. It also shows all required dimensions of all types of fittings.

The other side covers the world's most complete line of forged steel flanges. For every nominal pipe size, ½" through 24", it gives all essential dimensional and bolting data for all types of flanges in all weights. A particularly useful table (see reproduction) is that showing welding neck flange bores which enables you to determine the I.D. of any nominal pipe size without separate calculation. Thus the sheet gives you O.D. and I.D. of any weight of pipe.

The card is varnished to make it stand the steady usage you are certain to give it. To obtain your copy see your Taylor Forge distributor or **MAIL THE COUPON.**

TF

TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS

General Offices and Works: P. O. Box 485, Chicago 90, Ill.
Offices in all principal cities.
Plants at: Carnegie, Pa.; Fontana, Calif.; Hamilton, Ont., Canada

Please send me one of your fitting and flange sheets:

NAME_____

POSITION_____

COMPANY_____

STREET ADDRESS_____

CITY_____ ZONE____ STATE_____

507-1152 Mail to Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.

Main steam piping at Salem Harbor Station of New England Power, 1000° F and 1450 psi, supported by Grinnell Constant Support Hangers.

Problem:

PIPING THAT GROWS...

Solution:

GRINNELL ENGINEERED HANGERS

Eight . . . nine . . . ten inches of thermal deflection! That's not a bit uncommon in today's high temperature, high pressure systems. Very hard-to-come-by, though, is the skill necessary for dealing successfully with suspension problems resulting from *"piping that grows"* . . .

Large manufacturing facilities, expert technicians, and a lot of down-to-earth practical knowledge are needed.

Grinnell is America's No. 1 supplier of pipe hangers and supports, because Grinnell combines modern manufacturing with expert background knowledge gained during a century of piping specialization. Grinnell has developed hangers and supports for *every* piping need, from the simplest to the most complex. Grinnell, and Grinnell alone, can offer these advantages:

- Complete "start-to-finish" production facilities—including research, design, manufacturing, engineering and field service.
- Practical experience in every type of piping gained during the past 100 years.
- Coast to coast distribution—enabling "out of stock" purchases, anywhere.

Grinnell is always ready to cooperate with engineers and architects in the preparation of pipe suspension specifications. Call Grinnell for pipe hangers and supports.

GRINNELL MODEL L CONSTANT SUPPORTS maintain full safety factor in high temperature, high pressure systems. 3 physical structures accommodate maximum travel requirement of 2½, 5 and 10 inches; 16 sizes collectively cover numerous load ranges between 181 and 19,530 lbs.

GRINNELL PRE-ENGINEERED SPRING HANGERS — maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes. 16 sizes available from stock — load range from 74 lbs. to 9000 lbs.

GRINNELL VIBRATION CONTROL AND SWAY BRACES — dampen vibration, oppose pipe sway and absorb shock. 3 sizes give full deflection forces from 200 to 1800 lbs.; have initial precompressed spring forces from 50 to 450 lbs. respectively.

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

In the critical Cigar Conditioning Room of D. W. G. Cigar Corporation, Lima, O. **(home of such famous cigars as R. G. DUN, EL VERSO, and SAN FELICE)**, walls are ¼" "Century" APAC. This asbestos-cement structural board is also used in the Cigar Machine Room and Tobacco Conditioning Tunnel.

"These walls of 'Century' APAC are an added safeguard where temperature and humidity must be accurately controlled,"

says J. P. Weller, Master Mechanic—

No nurse in an infants' ward ever guarded her charges more jealously than D. W. G. Cigar Corporation watches over the thousands of quality cigars they turn out every day.

So when J. P. Weller, D. W. G.'s Master Mechanic, chooses "Century" APAC for the walls of the important Cigar Conditioning Room, you can take his word that APAC is an ideal material where temperature and humidity are accurately controlled.

And because APAC is made of mineral asbestos and portland cement, you know fire can't burn it . . . water can't soak it and termites can't eat it.

You'll find this asbestos-cement structural board gives you as low a first cost and maintenance expense (*never* needs painting!) as any comparable material you can use for interior or exterior walls . . . ceilings . . . partitions . . . and linings.

It goes on fast, too—big sheets (standard 4′ x 8′) can be cut or drilled and fastened easily with screws or ring-fettered nails. Write us for details about "Century" APAC . . . and name of your nearest distributor.

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873.

KEASBEY & MATTISON

COMPANY • AMBLER • PENNSYLVANIA

keeping a tool joint "jumping"

Twice the usual service with Airco Hardfacing Alloys!

Tool joint killers: Increased drilling depths — higher penetration rates—faster rotating speeds — these are the factors that add dollars to drilling and maintenance costs.

Unless — Airco Hardfacing Alloys are given the job of holding expenses to a minimum. For with these shock and abrasion-resistant alloys you may double your tool joint life—even under the toughest drilling conditions. And of extra importance: Not only is wear greatly reduced but correct box end diameters are maintained.

If you're being faced today with tool joint problems, there's an Airco representative near you who can help. Just write or phone your local office for the information you need.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT

AIRCO®

DEALERS AND OFFICES IN MANY PRINCIPAL CITIES

AIR REDUCTION MAGNOLIA COMPANY

A Division of Air Reduction Company, Incorporated

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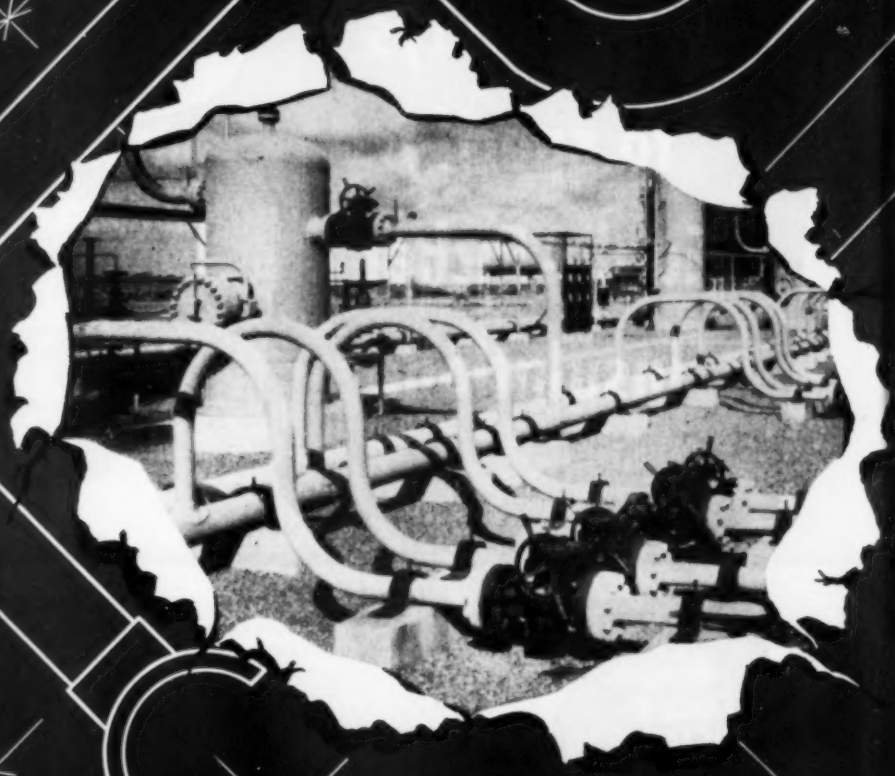
Southwestern Headquarters for Oxygen, Acetylene and Other Gases... Carbide... Gas Welding and Cutting Machines, Apparatus and Supplies... Arc Welders, Electrodes and Accessories

40 YEARS KNOW-HOW

in making blue prints come true ...20 years in Houston



TEXAS PIPE BENDING COMPANY

PIPE BENDS
PIPE COILS
WELDED HEADERS

Pipe Fabricators
HOUSTON TEXAS

OFFICE AND PLANT
301 FRIO STREET
WOODCREST-6-2659

Check the three big reasons why it pays to specify Eagle-Picher Insulation:

1.

2.

3.

Eagle-Picher "66" Insulating Cement—
All-purpose, rust-inhibitive, super-adhesive insulating cement. Great coverage, extreme thermal efficiency with "Springy Ball" pellets which won't collapse after application. Easy trowel application over all kinds of surfaces. Efficient up to 1800 F... reclaimable where temperatures do not exceed 1200 F.

THE EAGLE-PICHER

Cost-cutting insulations of top thermal efficiency

Insulating Cements

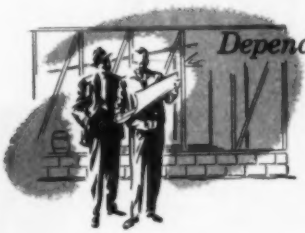
Fireproofing Cements

Supertemp Block

Blankets

Insulseal

Stalastic



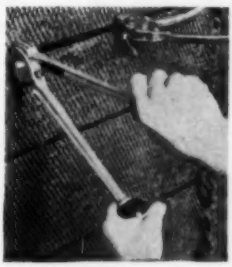
Dependable contractors, trained to strict factory standards

You can count on Eagle-Picher authorized contractors for uniformly high caliber service. Their qualifications provide assurance of a good job *every time* . . . efficient application of the Eagle-Picher insulation that best fits your needs.

Fast delivery from strategically located distribution points

The Eagle-Picher insulation line is stocked by distributors and authorized contractors coast to coast. The one nearest you will be happy to recommend insulating materials that give your equipment highest thermal efficiency . . . reduce fuel costs . . . help provide precise temperature control.

Eagle-Picher Supertemp Blocks—
A real insulating block—not a refractory! Unequalled for insulating quality. Weighs approximately 22-24 lbs. per cu. ft. Cuts easily with knife or saw . . . fits snugly over contoured surfaces. Monolithic structure . . . high refractory value. Withstands temperatures up to 1700 F. All standard sizes, from 3" x 18" to 12" x 36" . . . in thicknesses from 1" to 4".



Eagle-Picher Mineral Wool Blankets—
Made under factory supervision, these blankets fill your needs for fast, convenient insulating of flat or curved surfaces on larger types of heated equipment. The wool is felted and secured by flexible metal fabric . . . possesses outstanding physical and chemical stability for maximum resistance to water, steam, corrosive fumes and vibration.

COMPANY

EAGLE EP PICHER

General offices: Cincinnati (1), Ohio
Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

CHAPMAN LIST 960

the one Forged Steel Gate Valve that gives you this 4-WAY PROTECTION

Extra Protection Against Even Unusual Stress is provided by extra-strong stem-and-wedge-gate connection.

Repairs and Replacements Are Reduced by super-hardened seat rings and gate faces of stainless steel.

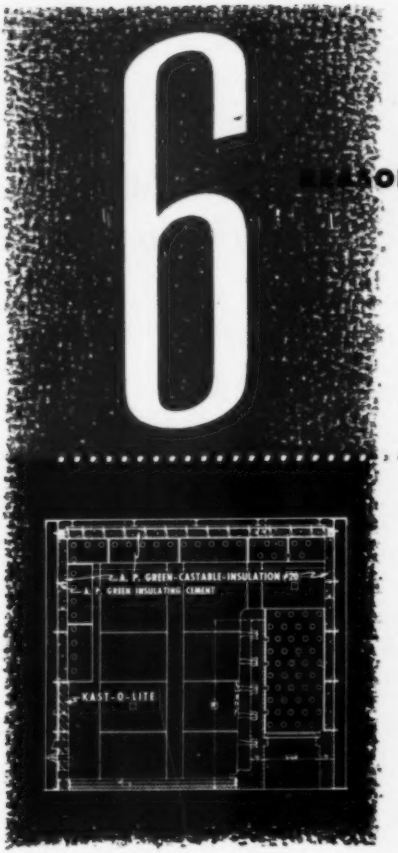
Longer-Lived Body and Yoke are of forged steel. And bolted follower has no threads on yoke to corrode.

No Seizing or Galling of Gate Faces because List 960's gates (when furnished with certain types of trim) are hardened by *Malcomizing* (patented Chapman process) to a minimum of 800 Brinnell.

An exceptionally wide range of services is covered by this small forged steel gate valve . . . giving you the same consistent top level performance on many different jobs.

Chapman List 960 Forged Steel Gate Valves are manufactured in sizes from ½" to 2" inclusive, and in these 2 types: (1) Rising stem with yoke (shown), and (2) Rising stem with inside screw. Bonnet joints are either gasketed or metal-to-metal. Pressure range: 2000 lb. at 100°F. — 380 lb. at 1000°F. For higher pressures, specify List 990. Send for illustrated Catalog No. 10.

THE CHAPMAN VALVE MFG. CO., INDIAN ORCHARD, MASS.



Cross section drawing of an oil heater in Gary, Indiana. This heater is one example of the numerous uses for A. P. Green lightweight castable refractories in the petroleum industry.

A. P. Green REFRACTORY PRODUCTS

6 REASONS WHY

A. P. GREEN

LIGHTWEIGHT CASTABLE REFRACTORIES REDUCE COSTS AND INCREASE EFFICIENCY IN OIL HEATERS AND OIL STILLS

For use in panel casing construction in new or old oil heaters and stills, A. P. Green castable refractories offer you these 6 advantages:

1. Lightweight insulating castables reduce heat loss . . . improve temperature control and heat distribution.
2. Securely anchored lining — gives long, trouble-free service.
3. Increases the performance and efficiency of the furnace. With fewer joints, air infiltration is reduced to a minimum.
4. Simplified construction — reduces erection time.
5. Lowers maintenance costs. Any tube section may be repaired by removing a series of the panels without disturbing the balance of the furnace arrangement.
6. Lower foundation costs due to the use of lightweight materials.

The A. P. Green Engineering Department will assist you with further information on the application of these materials to new units or the conversion of existing furnaces. Call your local A. P. Green distributor — he's listed in the yellow pages of your telephone directory — or write . . .

A. P. GREEN FIRE BRICK COMPANY

Mexico, Missouri, U. S. A.

In Canada **A. P. GREEN FIRE BRICK COMPANY, LTD.** Toronto 15, Ontario

DISTRIBUTORS IN THE PRINCIPAL CITIES OF THE WORLD

The castable is poured and anchored to the steel panels on the job site. The simple formwork has been removed and the panels are awaiting erection.

Interior view of side wall showing panels being erected.

View of outside panel casing.

These tubes go in to stay!

Thanks to CHASE ANTIMONIAL ADMIRALTY

(a patented alloy)

Here's the reason Chase Antimonial Admiralty* keeps heat exchanger tubes on the job year after year:

They've got *enough* antimony to resist dezincification. And antimony will not affect the metal's grain structure and won't weaken the tube.

When you get Chase Antimonial Admiralty Condenser Tubes, you're getting metal that *stays tough* . . . stands up under heavy stresses . . . lasts for years.

Years of use have proved Chase Antimonial Admiralty's superiority!

*U. S. Pat. No. 2,061,921

Special stocks of
ANTIMONIAL ADMIRALTY
Condenser Tubes in Chase Warehouses:
NEW YORK, BALTIMORE, NEW ORLEANS
LOS ANGELES
also carried by—
Vinson Supply Co., Tulsa
Standard Brass & Mfg. Co., Houston

Chase BRASS & COPPER

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

• *The Nation's Headquarters for Brass & Copper*

Albany†	Cleveland	Kansas City, Mo.	New York	San Francisco	
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Boston	Detroit	Minneapolis	Providence		
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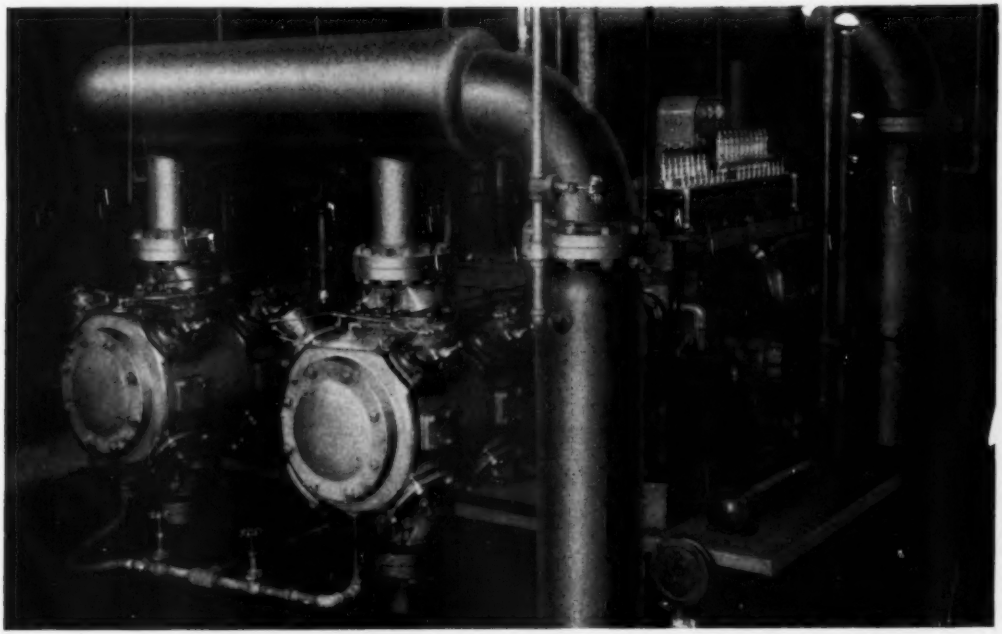
Cincinnati	Indianapolis	New Orleans	St. Louis		



SAVINGS... even before the word GO!

Great Lakes Refining selects the compressors that simplify erection and firewall installation

When Great Lakes Refining Co. was planning its new Houdriflow cat cracking unit at Blue Island, Illinois, one of the prime requirements was a low fire hazard compressor installation for vapor recovery service.

What type of compressor should be used? The decision was easy after Clark engineers made a thorough analysis carefully considering gas and steam engine driven units, motor driven reciprocating units and centrifugal compressors. Building all types of compressors, Clark was unusually qualified to make this comparison—*impartially!* Recommendation: Two Clark CMA-4, 300 bhp, Balanced/Opposed, Synchronous Motor Driven Compressors.

Of major importance was adaptability to firewall type construction. Having a single unit crankcase with the driving motor on the end, it would be a simple matter to isolate the motor from the Clark Balanced/Opposed Compressor. The shaft would merely extend through the firewall, with a simple packing gland sealing out the gas.

Costwise, Great Lakes Refining was ahead from the day the order was placed. Considerable time and cost in installation were saved by shipping the unit completely assembled. Vibration-free operation —*the result of perfect balance*— paid off in smaller foundation cost and will *continue* to pay off in practically maintenance-free operation.

For details on this truly modern compressor, write for Bulletin No. 118. For complete information on *all* your compressor problems, call in the nearest Clark representative for an unbiased answer.

CLARK BROS. CO. • OLEAN, N. Y.

Division of Dresser Operations, Inc.

Gas-engine-Driven • Steam-engine-Driven • Motor-Driven • Centrifugal

Offices in Principal cities throughout the World

CLARK

balanced/opposed
COMPRESSORS

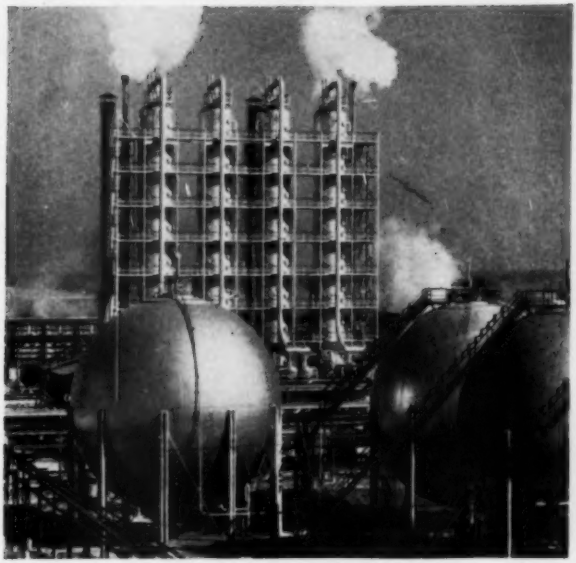
KON-TAK

a new
and
selected
bleaching
clay
of highest
quality
for
refinery
use

Baroid HOUSTON ☆ TULSA ☆ LOS ANGELES

BAROID SALES DIVISION, NATIONAL LEAD COMPANY

Main Office: Houston, Texas • P.O. Box 1675, Houston 1



ENDURO...and your "95%-plus"

• Your industry generally has been maintaining a minimum utilization factor of 95% . . . and higher. Helping you maintain that impressive "on-stream" rate is trouble-free equipment—much of it made from Republic ENDURO Stainless and Heat-Resisting Steels.

Strong, tough, long-lasting ENDURO stubbornly resists rust and corrosion. It resists the action of most acids and alkalies. Its hard, smooth surface discourages coking and fouling—is easy to wash down quickly during "off-stream" periods.

ENDURO maintains its great strength under prolonged exposure to scorching or sub-zero temperatures. And, because its strength-to-weight ratio is unusually high, ENDURO refuses to buckle or fail under pressure . . . even when you use it in thinner, bulk-saving sections.

File the name ENDURO with your plans for new and expanded plant facilities. Several analyses of ENDURO Stainless and Heat-Resisting Steels currently are available to help you stay on the high side of "95%". And, Republic stands ready to work with you at any time on future developments involving the use of stainless steels. Just write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

See and Hear
"THE STORY OF STAINLESS"

Full-color, 16 mm sound film —27 minutes running time. Dramatic . . . historic . . . interesting. Available to qualified groups without charge. Requires 16 mm sound projector. Send name of organization, type of projector, requested date to Ideal Pictures Corp., Dept. T-4, 65 E. So. Water St., Chicago 1, Ill., or write Republic Steel, Dept. K, Cleveland 1, O.

Republic
REPUBLIC STEEL
ENDURO STAINLESS STEEL

Other Republic Products include Upson Bolts, Studs, Nuts and Rivets—Pipe—Sheets—Plates—Electronite Heat Exchanger Tubes

DID YOU KNOW THAT
UNIVERSAL SERVICE PROTECTS
YOUR INVESTMENT 7 WAYS?

CONTINUED LABORATORY RESEARCH PROTECTS YOUR INVESTMENT

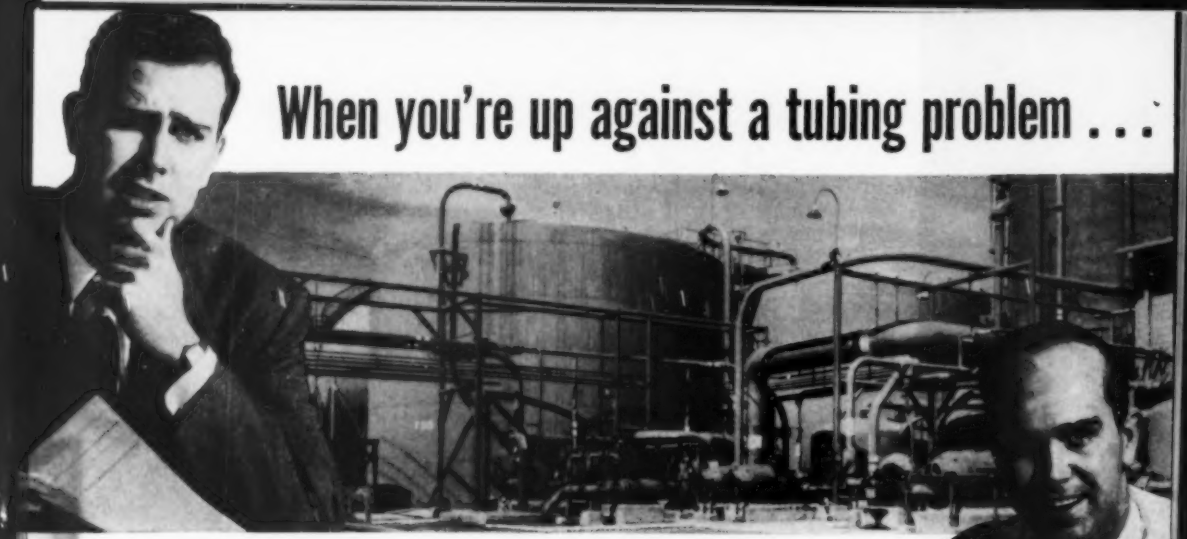
To provide modern processing methods and techniques leading to improvement of products from petroleum, Universal constantly conducts extensive research in the field of hydrocarbons. This continued study of intricate reactions in the laboratory enables the refiner to keep abreast of developments and to get the benefits of the collective thinking of some of the finest research minds in the industry.

As a result of these research activities, refiners have been able to achieve greater efficiency and economy of operation and to provide products that meet the demands of their individual markets—just one of the ways in which Universal service protects your investment.

UNIVERSAL OIL PRODUCTS COMPANY

UOP *General Offices:* 30 EAST ALGONQUIN ROAD, DES PLAINES, ILL., U. S. A.
Laboratories: RIVERSIDE, ILLINOIS

Universal Service Protects Your Investment through laboratory research . . . pilot plant studies . . . design and engineering . . . construction supervision . . . licensee instruction . . . post on-stream service . . . collateral services.



When you're up against a tubing problem . . .

Tubing Headquarters

can help you solve it!

WHEN the question of tubing comes up for a new installation or for replacement, don't cross your fingers and "take a shot in the dark" hoping that your choice will prove the answer to your needs. Play safe! Come to Tubing Headquarters. Tell National Tube what conditions are at your plant. The chances are that we have already helped other refineries handle similar situations . . . *and successfully*. In fact our files are filled with case histories, the results of laboratory tests, and actual field observations involving National Seamless Steel Pipe and Tubing under practically every condition of temperature, pressure, corrosion and exposure.

Out of this research and study have come important developments in tubing steel which enable National Tube to offer you seamless steel tubing, condenser tubes, heat exchanger tubes, and refinery piping in *24 different analyses*. Each of these 24 different analyses has been performance-proved to meet the specific conditions of corrosion and oxidation for which it is recommended.

We invite you to bring your problems to National Tube. Our tubing specialists will work closely with your own engineers to see that you get *just the right* tubes and piping for your particular requirements.

NATIONAL TUBE offers you
Seamless Steel Still Tubes
Condenser Tubes
Heat Exchanger Tubes
Refinery Piping
in 24 DIFFERENT ANALYSES

Carbon	7 Cr, ½ Mo
Carbon, ½ Mo	8 Cr, ½ Mo
½ Cr, ½ Mo	8 Cr, 1 Mo
1 Cr, ½ Mo	9 Cr, 1 Mo
1¼ Cr, ½ Mo	12 Cr, Al
2 Cr, ½ Mo	17 Cr
2¼ Cr, 1 Mo	27 Cr
2½ Cr, ½ Mo, ¾ Si	18-8
3 Cr, 1 Mo	18-8 Ti
5 Cr, ½ Mo	18-8 Cb
5 Cr, ½ Mo, 1½ Si	18-8 Mo
5 Cr, ½ Mo, Ti	25-20

All National Seamless Tubes are pierced from a solid billet of high-quality steel. This is the one manufacturing method that removes all doubt concerning uniform wall strength.

NATIONAL TUBE DIVISION, UNITED STATES STEEL COMPANY, PITTSBURGH, PA.
(TUBING SPECIALTIES)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL

TERRY

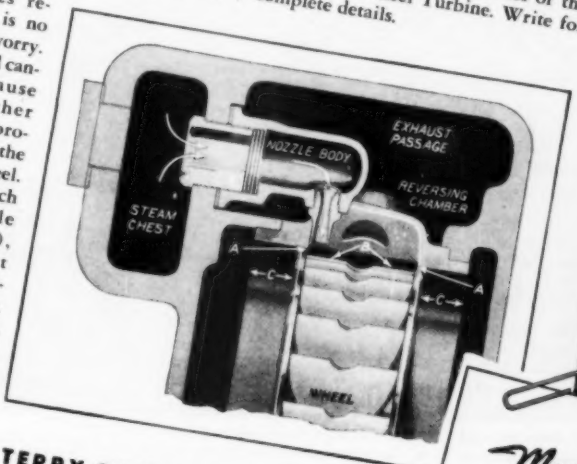
LARGE CLEARANCES take the "worry" out of Turbine Operation

In a Terry Solid-wheel Turbine the power-producing action of the steam in the wheel takes place on the curved surfaces at the back of the buckets. This unique design permits unusually large blade clearance—see B in the diagram.

Even if this clearance becomes reduced, there is no real cause for worry. The blades still cannot foul because they are further protected by projecting rims at the sides of the wheel. These rims, which also have ample clearances (AA), will take without damage any rubbing that may occur.

Side clearance, CC, is so large that end-play from external thrust will not damage the wheel. This clearance is one inch or even greater.

Large side and blade clearances are only two of the many features of the Terry Solid-wheel Turbine. Write for complete details.



THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1191

Memo

Send for a copy of bulletin S-116 which describes the many advantages of the Terry Solid-wheel Turbine.

BUILDING A GREATER AMERICA

Advance Guard

OR LOOKING AHEAD

Officially, there's no "Travel Bureau" to plan for the safety and comfort of "passengers" like fractionating towers, but Sun Ship workers must plan routes with expert care.

The man who built, in his cellar, a boat too big to go out the window, just didn't look ahead.

The industry that builds a fractionating tower more than 126 feet in length . . . 12 feet inside diameter . . . and weighing more than 180 tons . . . just has to know how to meet the problems of delivering it. Every problem that might be met along hundreds of miles of railway has to be known and planned for.

Knowing clearances and curves, on every foot of railway routes is part of the job. Planning to meet and master those problems, or to select routes which eliminate them, is part of Sun Ship's job when it builds chemical and refinery equipment.

The Sun-built refineries and chemical equipment serving in every part of America and in many foreign lands shows how well Sun men and management have mastered the problems of delivering the equipment they have produced in helping build a greater America.

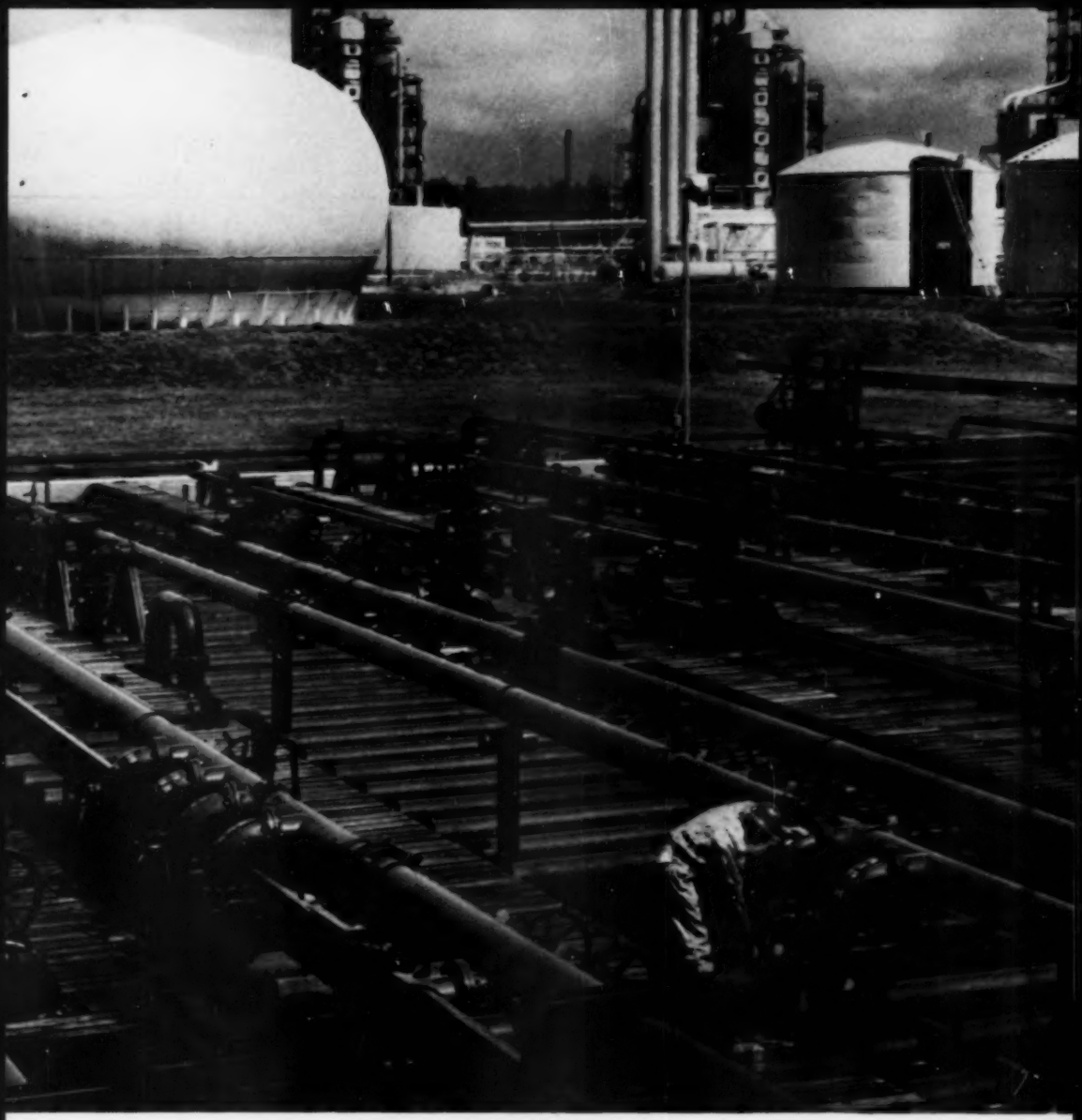
Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY



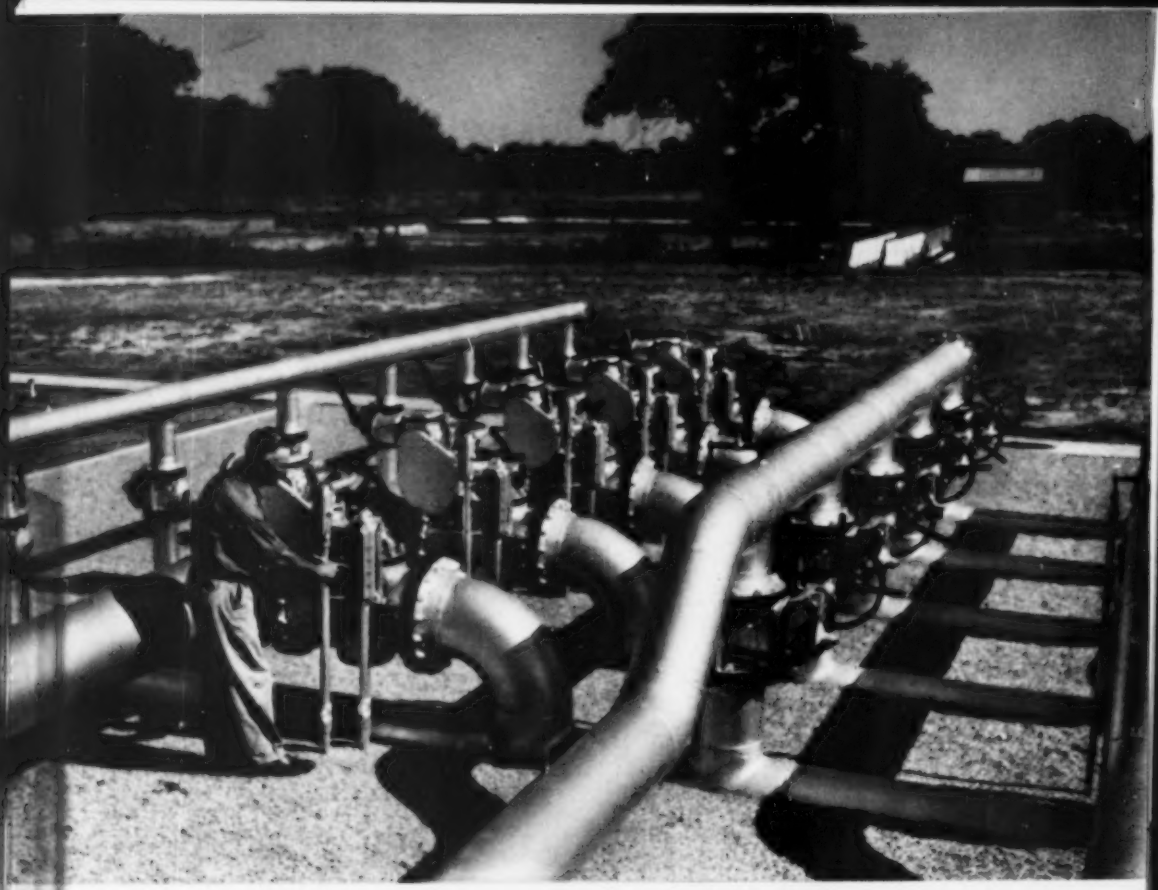
Manifold Control–THE SAFE, SURE NORDSTROM WAY

Often, in a single manifold, Nordstrom valves will be used to control several forms of gas, a variety of petroleum derivatives, or a diversified group of hard-to-hold chemicals.

Because of their versatility . . . because they are available in so many different metals, sizes, pressure classes and styles . . . because they are doubled-sealed with lubricants especially compounded for specific services . . . because they open and close on a quarter-turn—these are among the reasons Nordstroms are ideal for manifold service.

In your control manifolds—consider the advantages of specifying Nordstrom lubricant-sealed valves throughout.

Rockwell | **Built**
Another Rockwell Product | **Nordstrom Valves**
LUBRICANT SEALED TO KEEP UPKEEP DOWN



How To Save Money On Valves

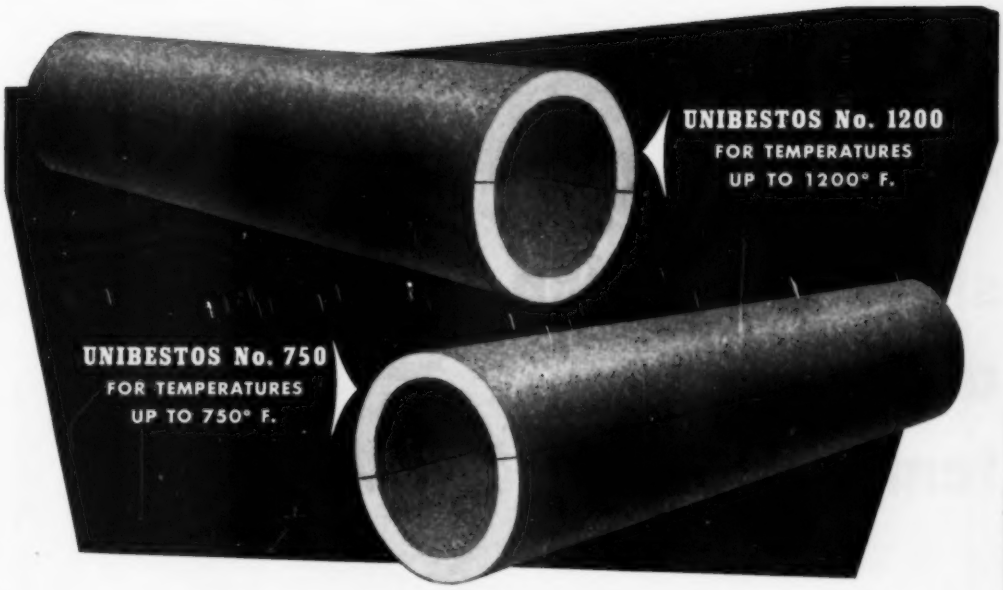
These installations are illustrations of the best way to save money on valves: specify Nordstroms in the first place. In original cost, Nordstrom valves often cost no more; over the life of the line or the equipment they serve, they almost always cost much less.

Nordstroms, the original lubricated plug valves, have proved their economy through 30 years of hard service in several thousands of different types of processes in gas, petroleum, chemical and other technological industries. That experience, that performance, is your reference. Nordstrom Valves are built by the Rockwell Manufacturing Company, 400 N. Lexington Ave., Pittsburgh 8, Pa.

Rockwell Built

Another Rockwell Product **Nordstrom Valves**

LUBRICANT SEALED TO KEEP UPKEEP DOWN



These famous UNIBESTOS twins cut heat loss and surface temperature

HIGH EFFICIENCY IS UNIMPAIRED BY REUSE OR CONTINUOUS SERVICE

When yon insulate with Unibestos you can be sure of *prolonged* effectiveness, for this durable, high quality insulation resists all service hazards. It's unaffected by moisture, steam, fumes . . . withstands impact and vibration . . . won't shatter, crumble, powder, or dust to contaminate the atmosphere under normal service conditions.

Unibestos is easy to cut and fit . . . brings you the added economy of *single-layer* application . . . may be removed and reused repeatedly without damage or loss of efficiency. Adjacent sections can be stapled together to prevent separation due to expansion.

Phone your Unarco Distributor for *money-saving* Unibestos in cylinders, half-rounds, or blocks.

UNARCO

UNION ASBESTOS & RUBBER COMPANY

Dept. D-11 332 SOUTH MICHIGAN AVENUE • CHICAGO 4, ILLINOIS

This assembly stays on the job at elevated temperatures

For an effective, economical bolting combination, one which stays on the job in installations involving high temperatures and high pressures, use the Bethlehem Continuous-Thread Stud, together with two Bethlehem Quenched Nuts.

This stud-and-nut combination is ideal for lengthy service in difficult bolting applications because of the way it stands up under fluctuating temperatures and pressures.

The Bethlehem Continuous-Thread Stud has no point of thread-runout. This means that stresses which could cause early stud failure by being concentrated, are instead well distributed over the full working length of the stud.

The Bethlehem Quenched Nut, made from .40 to .50 carbon steel, is formed by forging and extruding hot steel in a forming die. It is then quenched and tempered. This method of manufacture arms the nut with sufficient strength to break virtually any stud or bolt on which it is used.

Both the Bethlehem Continuous-Thread Stud and the Bethlehem Quenched Nut are furnished in a wide range of sizes. Together they form an effective assembly for difficult bolting applications. For full particulars, write to the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

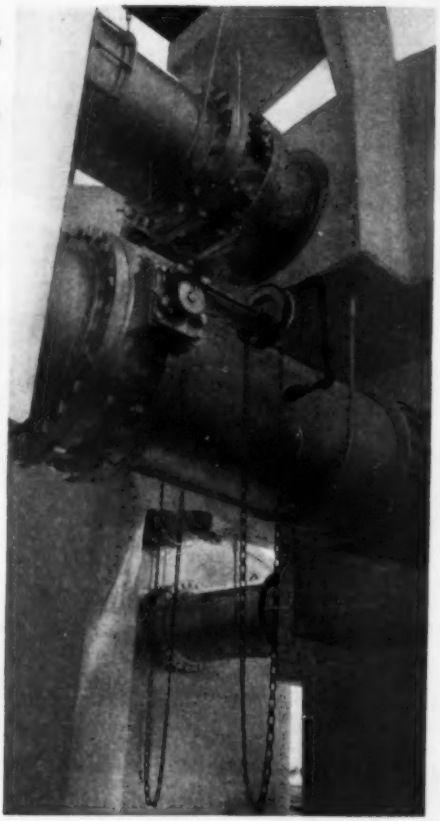
Bethlehem supplies every type of Fastener

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

For Operating Ease in Inaccessible Locations

INSTALL R-S CHAINWHEEL VALVES



Few Chainwheel Turns. R-S Valves are completely closed from the fully open position by the movement of the valve vane through 77½° of arc. Operating ease is one of the chief advantages of R-S Valves.

Economy in First Cost. R-S narrow face-to-face design results in minimum number of working parts, less metal, less machining, lower weight and less supporting structure—hence economy in first cost.

Accurate Engineering. Body assemblies are accurately engineered mechanically and metallurgically. A. S. A. standards are equaled or exceeded in every detail.

Low Pressure Drop Saves Power. In the open position the streamlined vane causes a Venturi action. Pressure drop is therefore exceptionally low. Pumping costs are reduced accordingly.

More Control Rangeability. Power-controlled prime movers delivering 15 foot-pounds to 38,000 foot-pounds of torque open or close at any desired speed. Full closure requires one second to ten minutes depending on requirements and the type of material controlled. Positive shut-off is obtained with a rubber seat.

Self-cleaning. There are no pockets to house sediment, no change of flow direction to create turbulence or wire drawing and therefore less likelihood of erosion and cavitation.

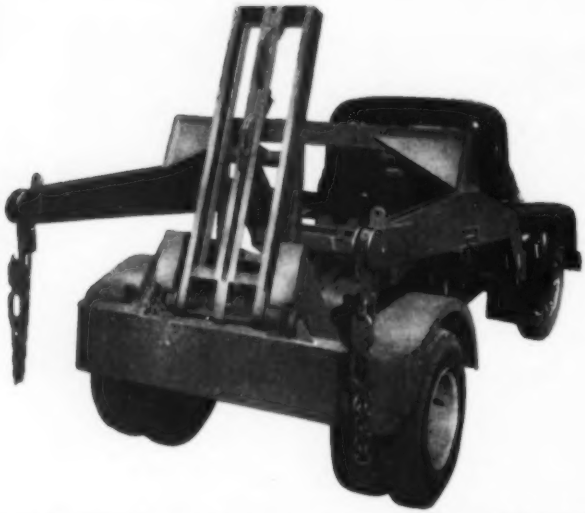
Maintenance Practically Nil. Every R-S Valve is designed and constructed for rugged service and provided with safety factors to give complete satisfaction in the service for which it is designed. Packing trouble is not common to R-S Valves since the shaft moves only with an oscillating motion.

Consult your local R-S Valve Engineers, or write direct.

R-S PRODUCTS CORPORATION • 4600 Germantown Ave., Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES



WHY USE 3 TO 5 TRUCKS... WHEN ONLY ONE WILL DO?

In many plants a Dempster-Dumpster, like the one above, operated by only one man, the driver, has replaced 3 to 5 conventional trucks and crews. The reason for this is that one truck-mounted Dempster-Dumpster serves scores of Dempster-Dumpster Detachable Containers up to four times the capacity of the average dump truck body. These containers are built in a wide variety of designs best suited to the type of materials handled—be they bulky, light or heavy . . . solids or liquids . . . trash or rubbish. Containers are conveniently located at accumulation points inside and outside buildings. To illustrate the flexibility of the Dempster-Dumpster System in handling all types of materials in your plant, we show, at right, a few of the dozens of Dempster-Dumpster Containers built to meet every bulk materials handling need. And remember, one truck-mounted Dempster-Dumpster handles all containers, regardless of capacity or design.

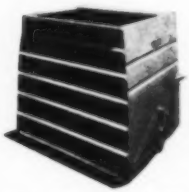
The Dempster-Dumpster System eliminates standing idle time of crews and trucks . . . eliminates re-handling of materials . . . increases efficiency, sanitation and good housekeeping . . . cuts cost of truck equipment and operation tremendously. Without question, it's the most efficient and lowest cost method of bulk materials handling by truck ever devised! The chances are this system will save you thousands of dollars annually. This equipment manufactured and sold exclusively by Dempster Brothers, Inc.

WHEN A CONTAINER IS FULL, the Dempster-Dumpster picks it up, hauls to destination and dumps the materials or sets load down intact. These three simple operations, shown above, are hydraulically controlled by driver in truck cab.

Drop Bottom Container built up to 10 cu. yd. capacity to handle heavy materials.

Tank Type Container meeting A.S.M.E. specifications. Capacities up to 1,200 gallons.

Tilt Type with Converged Lip for handling fine aggregate, wet or fluid materials.



Drop Bottom Pressed Steel Type for lighter service.

Universal Type built up to 12 cu. yd. capacity with top and end doors.

Five cu. yd. container with swivel casters for handling waste blast sand.

DEMPSTER BROTHERS, 5112 Dempster Bldg., Knoxville 17, Tennessee

[Letters]

Decimal Classification System

Dear Sir:

I have read with considerable interest the article by W. L. Bolles published in the May, 1949, issue of the PETROLEUM REFINER entitled "Guide For Filing—Decimal Classification System For Chemical Engineering."

It would be greatly appreciated if you would advise relative to the current classifications which you have developed including the additions since 1949. I am considering adoption of your system to my technical data files and am therefore interested in up to date information reference same.

I am sure that many have found your article quite interesting, and I believe that a revision might be worth while to the petroleum industry.

R. R. Gumaer
Technical Assistant to the
Vice President—Manufacturing
Pan-Am Southern Corp.
New Orleans.

Ed. Note: *Our supply of reprints of this widely accepted paper is depleted. Mr. Bolles does not plan to revise the article at present time. We agree that such a revision would be worthwhile.*

Technical Unions

Dear Sir:

In the discussion of the pros and cons of technical unions in your August issue, you imply that there are only two courses of action—either all union or all management. How about giving some coverage to the intermediate course—the non-union type of organization devoted to improving the economic status of the non-supervisory technical man?

R. L. Chatham
Chemical Engineer
Cities Service Refining Corporation
609 Kirkman St.
Lake Charles, La.

Ed. Note: *Although an article along this line would be interesting, our plans do not call for such a coverage in the near future.*

Process Issue and Sittig's Article

Dear Sir:

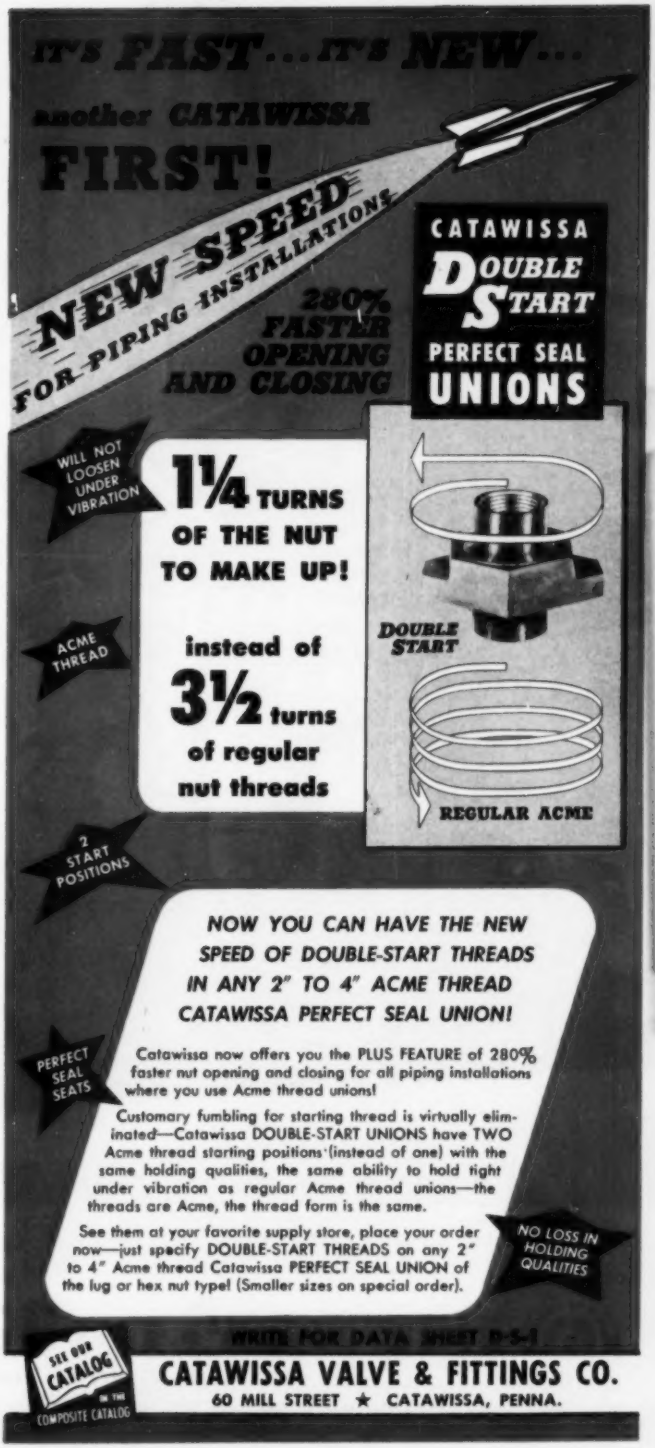
I would like to congratulate you on the excellent article by Marshall Sittig on "Catalytic Cracking Techniques in Review." This is the best exposition of the subject which I have seen yet and it certainly is a big contribution to petroleum literature.

The Process Issue of your magazine also presents an excellent review of the existing commercial processes. They are brief and, at the same time, to the point. The accompanying flow sheets are a tremendous improvement over those which were published in the past. They give the essence of the processes without encumbering details.

V. A. Kalichevsky
820, 20th Street
Beaumont, Texas

Dear Sir:

Your recent process issue of the Refiner was certainly well received by the technical men in our company. We would like to receive an additional copy of the process if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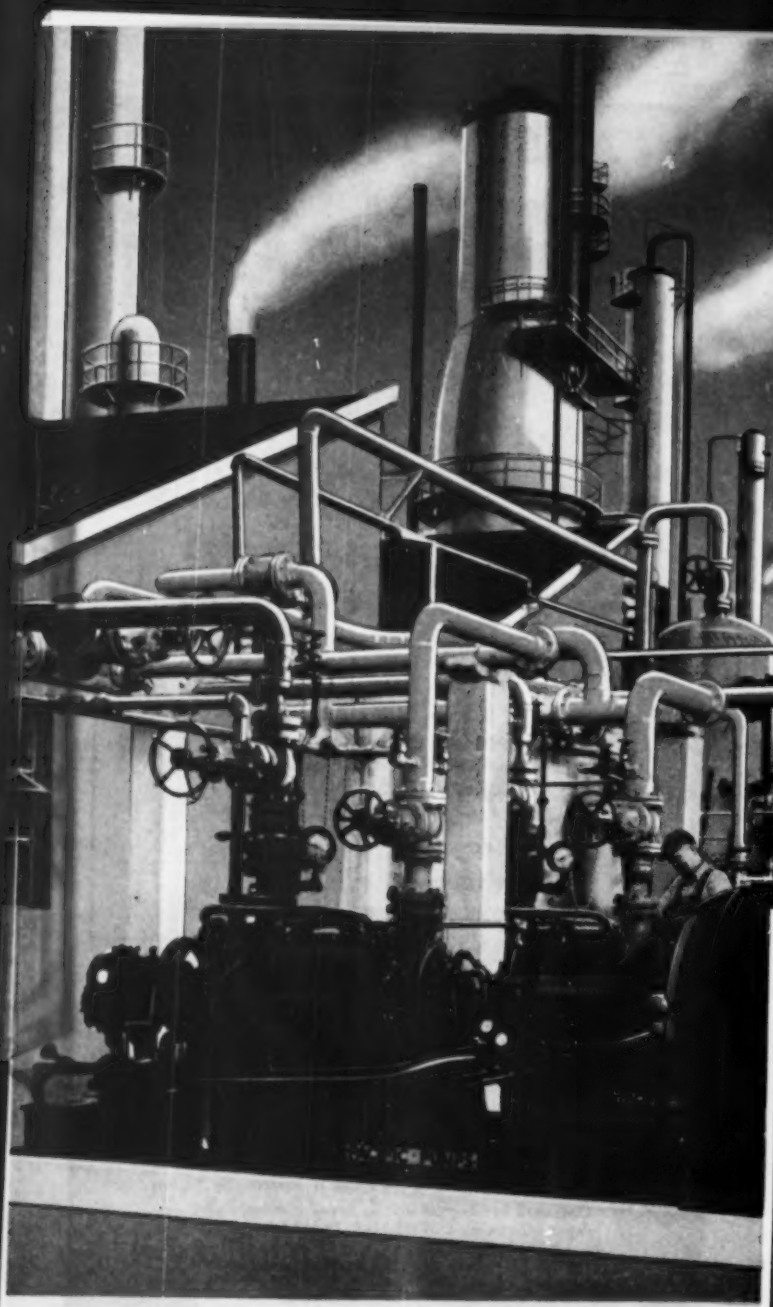

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you have any available. In the event that you reprint the process issue, we would like to receive 10 additional copies and in the event that you reprint Mr. Sittig's article on catalytic cracking we would like to receive 25 copies.

Clyde Berg, Manager
Development Department
Union Oil Company of California
Wilmington, Cal.

Dear Sir:

Please accept my congratulations on your September issue, which was excellent indeed, as are most of your issues.

We most definitely will want 1000 reprints of Mr. Sittig's article.

B. H. Weil, Head
Information Division
Ethyl Corporation
Detroit, Michigan

Dear Sir:

We are very much impressed with the two Special Process sections in your September Refiner. If by any chance you are going to run reprints on these we would like to have two hundred copies of each. If not, please send us six more copies of the magazine, and bill us accordingly.

C. F. Pollen
M. H. Detrick Company
Chicago, Ill.

Dear Sir:

PETROLEUM REFINER can well be proud of its Process Issue. It is probably the most outstanding and complete guide to petroleum processes in the industry today.

We are glad that we could be a contributor to this issue and are particularly pleased with the presentation of the processes we submitted.

We are now wondering if separate reprints of the processes we presented are available. Please give us what information you have regarding these reprints.

Fred C. Neuhart
Stone & Webster Engineering Corporation
Badger Process Division
49 Federal Street
Boston, Mass.

Dear Sir:

Ever since I heard about your (Dr. John McKetta's) transfer from the university to the publishing field several months ago, I have been wanting to wish you success in your new venture. Last night I had time to read the September, 1952, issue of PETROLEUM REFINER. I was very favorably impressed with your foreword on page 97 and with the Process Section and Marshall Sittig's article.

In spite of the fact that a great many other journals cross my desk I still take the time to go through each issue of the PETROLEUM REFINER as a means of keeping acquainted with the latest developments in that branch of the oil industry.

O. Edward Kurt
Assistant to Director of Research
Ethyl Corporation
Detroit, Mich.

Ed. Note: *Reprints of the combined Process Section and Sittig's article are available at $1.00 each. Please remit with your order and address all orders to Reprint Department, Petroleum Refiner, P. O. Box 2608, Houston 1. See item in "Look Box," page 75 of this issue.*

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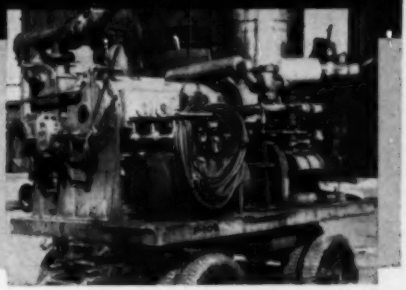

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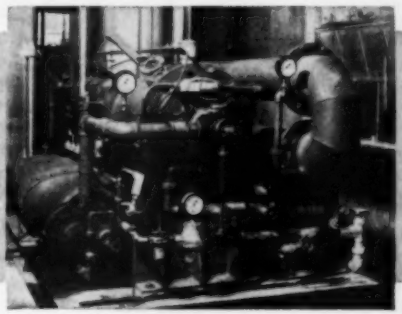

Installation of three R-C Inert Gas Generators similar to this one helped one large plant save $6,000 per month insurance premiums, as well as substantially reduce danger of production losses caused by explosion or fires. Capacity of each unit, 6,000 cfh.

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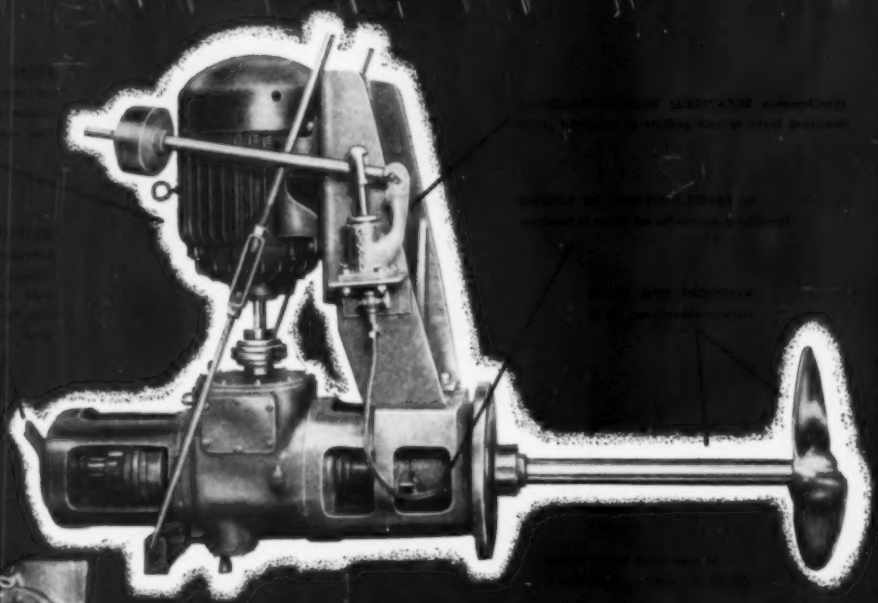

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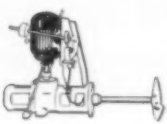

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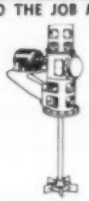

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PETROLEUM REFINER

The LOOK BOX

You Can Write Too

HOW MANY times have you wondered just what is required of an author in publishing a magazine article and, in particular, what are the editorial policies of our magazine? As a subscriber to PETROLEUM REFINER, you are going to find out the answers to those questions in the very near future. We are mailing to you a booklet, prepared by our staff, which gives helpful hints on writing articles and also the editorial policies of our magazine.

Writing for a magazine does present a special approach. Magazine articles are not the same as a company report though the content is similar. They are not the same as a college thesis, though the data may be the same. Though convention papers are often prepared from the standpoint of future publication, they require special attention to make them worth publishing. You will find in this booklet just what is the special approach of a magazine article.

Getting down to details, the booklet presents outlines for six types of articles—construction, process, operations, maintenance, safety and management-personnel. You can use these as checklists when you organize your material. What's more the booklet will tell you how to write a title or a head, lead (introduction) and then follow with the body of the article.

What is hoped is that those of you who have never considered writing an article will now be able to approach this essential part of your profession with the same assurance that you write a check (or does that always shake you up?). This is not to underestimate the value of the booklet to those of you who have already written articles or to those of you who will never write an article. We want all our subscribers to be on the "inside" of writing. If you get as much out of reading the booklet as we did writing it, you will sit right down and start organizing into an article that problem which you faced the hard way.

Penny Wise and Pound Foolish

REFINERY managers are giving lots of thought these days to the morale of their technical employes. And certainly they should. Competition is keen for the services of the technical man. Process-wise, refineries are more and more dependent on technical services, even for routine operations. And, of course, all good administrators have a perfectly human interest in their employes.

The technical man's work is unique. He is paid to think—and to think creatively. No amount of compulsion can increase the quality and quantity of his productivity. The hourly worker is in an entirely different category. His work is spelled out for him. To minimize mistakes, every effort is made to reduce his efforts to simple routine. The best machinery and tools available are bought for him.

The point is this: Why shouldn't refinery management be just as eager to provide the best possible tools for the technical man? His productivity is a function of the quality of his tools. Better tools are about the only thing the management can give him that will make it possible to speed up his work.

What are these tools? First off, the technician needs a good office environment, with a private office as the ultimate goal. Secretarial help should be convenient and efficient. Library facilities should be adequate. Helpful tools such as calculators should be at his fingertips.

Expensive? Sure it is. But a calculator costs $700 and a machinist's lathe might cost $25,000. A bad piece of work from a machinist might cost you $10 for another chunk of metal. A bad mistake by an engineer might cost you $10 million!

After Oil Progress Week, What?

OIL PROGRESS Week has come and gone. Can we now sit back on our hands and wait for the next one to roll around? One oil company doesn't think so and has taken action this year to train one member of each refinery personnel department as a community relations specialist.

Behind the creation of these specialists is the basic idea that a company is an integral part of the community in which it operates. What the specialist does is to link the refinery and community, promote understanding and provide information.

Training the specialists is no small matter when it is realized what such a program can do. The specialist must first of all be well acquainted with his company's history and organization. He must be familiar with the entire industry's public relations program and with surveys and other means of keeping informed about public opinion. Such techniques as how to gather, write and edit news stories and radio scripts must also be among his working tools. Ultimately, the program will bring public relations to the community level and provide "Oil Progress Weeks" throughout the year.

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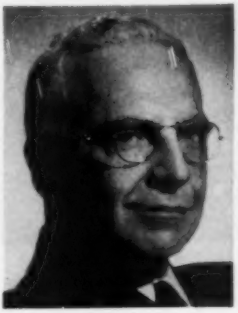
[The Look Box for November]

Our Synonym for Unique

MUCH ABUSED by loose usage, the word *unique* is defined by Webster as "single; sole; being without a like or equal; single in kind or excellence." Keeping within the strict meaning of the word, we have a synonym for unique in the form of a person whom many of you have met. He is a man who is singular in the number of articles which he has contributed to petroleum refining trade publications. He is without an equal in his inspiration to young technical men in Magnolia Petroleum Company's refinery at Beaumont. He is a man whom the industry regards as unique. He is V. A. Kalichevsky.



Kalichevsky

Just Around The Corner

EVERYONE likes a bargain. Next month we are doing our very best to give you an extra special one. Seven of the top men in the refining and petrochemical industries have pooled their efforts to give you a first-of-its-kind presentation.

The annual Instrumentation Issue is tailor-made for the instrument user and designer. High blown theory has been deserted and the authors have got right down to brass tacks to give you a practical, working handbook.

These questions will be answered for you: just what instruments are available, how accurate are they, where should they be used, how can you tell when they're obsolete, what are the latest developments? You can bet your hat that this is one issue you'll keep for your permanent files.

We Hit the Jackpot!

MAGAZINE publishers receive reprint requests with mixed emotions. Undoubtedly they are a gratifying indication of the readers' interest in the magazine. Unfortunately, printing and mailing of reprints is usually a losing money proposition. In our business, as in yours, profit is derived solely through application of mass production techniques.

There is another angle to the problem, and one which has always controlled the thinking of the management of PETROLEUM REFINER. We are in business to render a service to technicians and executives in the refining industry by providing technical articles that will be useful in their work. If the diligence and good work of our authors and editors are rewarded with a large number of requests for reprints of these articles, we have a moral obligation to comply with the requests.

The September Process Issue, including Marshall Sittig's monograph on catalytic cracking, apparently hit the jackpot with you readers. One thousand extra copies of the issue were printed. These were delivered, primarily to new subscribers, within three weeks after our publication date. As of November 1, 2300 additional reprints have been ordered.

We have decided to reprint both the Process Section and Sittig's article in a single, huge 144-page volume. These are available to you at a price of $1 per copy.

Thanks again for your heartening response to this issue. We hope the decision to reprint will make it possible to satisfy any and all requests.

Refined Stocks In Good Supply

IF THERE ARE any cold homes this winter, it won't be the fault of the nation's refiners for that segment of the industry has accumulated the greatest amount of heating oil in all its history. No matter what the winter months may bring, there are now adequate distillate fuel stocks in the U. S. to meet heating needs. Inventories of the other principal refined products are similarly in good position.

Shortly after the middle of October, distillate stocks reach 121 million barrels for the first time in the industry's history, and which amounted to 13 million barrels more than inventories of a year before. Fortunately, supplies in the heavy consuming East Coast area accounted for nine million barrels of the increase. In addition, the Gulf Coast region, which is the principal supply source for the East Coast, had two million barrels more than it held a year ago.

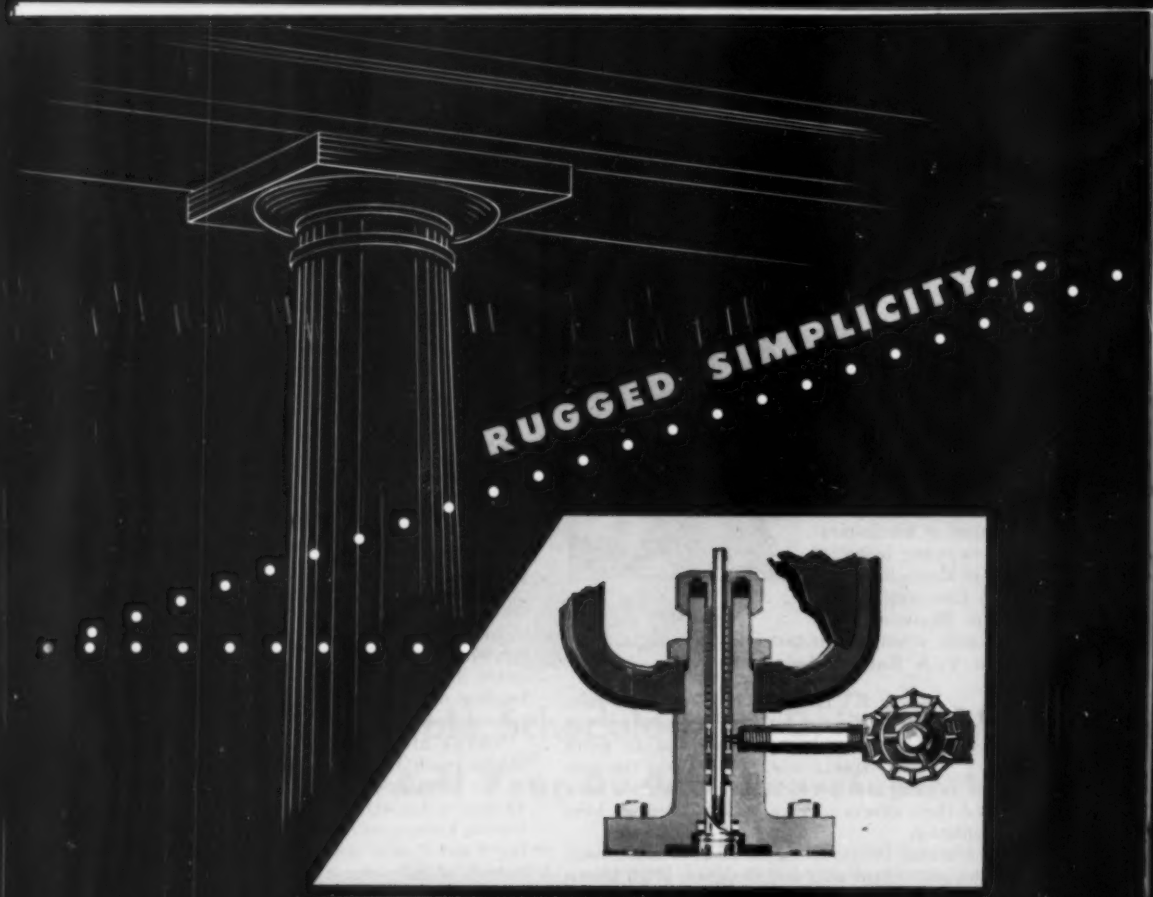
The Mid-Continent region has in some past years experienced spotty fuel oil shortages, but there now appears to be ample supplies for this season. The region comprised of Oklahoma, Kansas, Illinois and Indiana, has four million more barrels of the light heating oil in storage than at this time last year.

Current inventories of gasoline are now practically the same as were held at the beginning of the 1951 winter. This is considered satisfactory, with the exception of Mid-Continent stocks being higher than usual.

With refined products stocks in good supply, refinery operating schedules can be held below the seven million-barrels-per-day rate of July, August and September. That would help prevent gasoline stocks from becoming excessive during the winter season.

"Relatively speaking, gasoline is the cheapest major product on the market today. Keeping prices comparatively low has played a large part in stimulating the sixfold expansion of American Industry since 1916."

DR. ROBERT E. WILSON, Chairman
Standard Oil Co. (Indiana)



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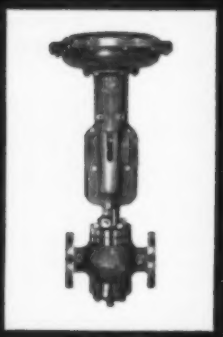

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What Prompts Progress?

Dr. John J. McKetta, Jr.
Editorial Director, Petroleum Refiner

PETROLEUM REFINER does not publish technical information without the full approval of the refining company concerned. This is an inflexible policy. On occasion, our editors have talked with refinery administrators who were reluctant to publish the technical work of their employes. Their philosophy is this: "What's in it for us? Why should we help our competitors by giving them the results of our good work?"

Our answer to these men has been this: There is plenty in it for you. Here are the reasons why you should do everything in your power to encourage your men to publish their work:

➔ You have a moral responsibility to repay in kind the information and ideas your company has obtained from the published work of others.

➔ Well-written articles by members of your staff bring recognition of professional talent (no one could prefer that his organization be a professional hermit). This recognition has a positive prestige value for your company.

➔ The prestige afforded the author-employe is his just due and right as a scientist.

➔ America is dependent on the technological progress of its industries. Efficiency is necessary to progress, and wasteful duplication of technical work cannot be tolerated.

Those are the reasons why you should spare no efforts to take full advantage of the channels of communications offered you.

First, there is the matter of your moral responsibility to mankind. Plato, and his student, Aristotle, were the first to publish the results of their scientific investigations. In the ensuing 2300 years, millions of words of scientific treatises have been recorded for posterity. Right this very minute, someone in your refinery is using data and information developed by a man who is outside of your organization. The technical literature is the very foundation of modern science. Is your company making its contribution, or is the flow of information on a one-way street?

Millions of dollars are being spent annually to improve the public relations of your company and others. An entire week has been dedicated to the thought that "Petroleum Is Progressive." Additional large sums are now being spent in the recruitment of college graduates. How do these young men form their opinions of the different oil companies? One principal source of acquaintanceship is through the by-lines of authors and their company affiliations. The number and type of technical articles is regarded by many as a measure of the progressiveness of a company. How do you stack up with your competitors on this score?

Your most inexperienced technical employe can rattle off the names of a dozen outstanding men in the oil industry. He learned of them through their writings in the literature. The number and quality of published articles has long been the criteria for judging the competence of a scientist. Your employes value highly the prestige associated with publishing their work. Are you being fair, making certain that no unreasonable obstacles are placed in the path of their writing? Or do they feel that their job responsibilities are so great that they cannot spare the time?

We have all marked with pride the rise of America to her position of world leadership. You and I feel that this rapid ascension has been due in the main to technical progress. Yet each of us is aware of the monstrous inefficiency of every company doing its own development work without recourse to the efforts of others. If you suddenly found that the men in your organization were not reading their trade press or were uninterested in hearing or learning of the papers presented at their professional meetings, you would have a real cause for concern. What is the very first thing a research engineer does when he begins work on a problem? He combs the literature for any information that may have been recorded by others who have preceded him in the field. This assures maximum efficiency and minimum waste of his time and his company's money.

These thoughts have not been directed at the majority of oil company executives, but rather at a diminishing few. Yet they need to be said—not from our own selfish standpoint (as is explained in the final paragraph) but in the interest of the employe and the company itself, and in the unselfish interest of putting every truth into the idea that Petroleum is Progress.

One final thought, and this is only to get the record straight. PETROLEUM REFINER is not suffering from a dearth of editorial material. In its 30 years, it has won the reputation for being the leading publication in the petroleum refining field. It has an editorial staff that can not be matched by any of its competitors. The fact remains—much first-class work is never published. The publication policy of oil companies is as different as daylight and dark. Some leave no stone unturned to encourage its employes to write and to minimize the difficulties in clearing the material for publication. Others are as stony silent as the Sphinx. We hope, for your sake and ours, that you are not in this last category.

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With the men whose job it is to keep things going Elliott turbines are regarded as the greatest worry-eliminators in the industry. Bulletin H-16 tells why. Write for it.

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TABLE 1

U. S. Total Demand

(Figures in Thousands of Barrels Per Day)

DOMESTIC	1951	1955	1960	1965	1967	Increase 1967 Over 1951 (Percent)
Gasoline	2,987	3,545	3,910	4,230	4,350	46
Kerosine and Distillate Fuel	1,569	1,869	2,064	2,210	2,260	44
Residual Fuel	1,544	1,648	1,716	1,823	1,980	20
Other Products	943	1,238	1,490	1,727	1,810	92
Total Domestic Demand, All Products	7,043	8,300	9,180	9,990	10,280	46
Total Exports	423	165	125	120	120	−72
Total Demand, All Products	7,466	8,465	9,305	10,110	10,400	39

1967—What Will Be The Product Demand?

Despite tremendous prospective demands, the petroleum industry will supply all needs if the American people will create a proper environment.

John W. Boatwright
Standard Oil Company (Indiana)
Chicago

AUTHORS OF articles such as these should either present the assumptions underlying their work, or they should indicate that the work is based upon the broad assumption that present economic controls will be eliminated and that an industry free to make decisions on economic considerations will be re-established. The latter course has been followed here. But there are, and will be, many economic problems which—depending upon the manner in which they are met—could greatly modify anticipated achievements. These will be touched upon briefly.

Anticipated Demand

The forecast of petroleum demand has been made giving recognition to the nation's total output of goods and services. No attempt was made to time a business recession or recessions, although this possibility was clearly recognized. In reviewing a 15-year time period, it is believed that the basic growth factors of the economy are more significant than annual deviations which may occur about that growth curve.

The anticipated growth of population, the expansion of industrial production, capital investment in new plants and durable equipment, the employment level, and other underlying basic economic trends were studied. Individual uses of petroleum were analyzed against that background. Total energy needs and the shifting proportion of the total supplied by petroleum, transportation requirements represented by number of units and consumption per unit, radiation units installed and requirements per annum, and industrial processing with petroleum products were analyzed from historical data and probable future needs. Agricultural and other off-the-highway needs for gasoline and other products were studied. All in all, several hundred indices of change were analyzed to the best of our ability in order to ascertain the probable future needs for petroleum products. Composite results are shown in Table 1.

Here are the more salient features of this forecast:

1) Total domestic demand for petroleum products is forecast to increase from 7,043,000 to 10,280,000 barrels daily by 1967, or a 46-percent gain. Exports should decline as a result of increased refinery capacity built in foreign lands. Reflecting the influence of this decline in exports, total demand for all products should increase from 7,466,000 to 10,400,000 barrels daily, or an increase of 39 percent.

2) The forecast of domestic demand for gasoline, representing a 46-percent expansion, reflects our guess of growing military needs as well as the increased requirements for civilian uses. Incidentally, the growth in gasoline requirements would have been higher had it not been for the competition we anticipate from the use of liquefied petroleum gas by trucks, tractors, buses, etc.

3) The increase of 44 percent for kerosine and distillates reflects the growth of jet-fuel utilization, the continued trend to dieselization, and the growth of present uses and new uses for the product.

4) The forecast of demand for residual fuel represents the smallest increase of any of the product classifications. Utilization of this product, by types of industries, presents contrasting trends—some increasing and some declining. Probably the most significant industry trend recognized was that oil-fired steam locomotives would be almost entirely converted to diesel fuel considerably prior to 1967.

5) The most significant increase forecast applies to "other products," including lubricating oils, asphalts, waxes, petroleum chemicals, coke, still gas, and liquefied petroleum gas. The sizable increase in volume of liquefied gas, representing a gain of 175 percent, explains the major proportion of growth anticipated for this class of products.

TABLE 2

Domestic Availability vs. Total Demand

(Figures in Thousands of Barrels Per Day)

YEAR	Domestic Availability of Crude Oil and Natural-Gas Liquids	Total Demand, Including Exports	Margin of Domestic Supply Over Total Demand
1950	7,123	6,812	311
1951	7,537	7,467	70
1955	8,792	8,465	327
1960	10,016	9,305	711
1965	10,736	10,110	626
1967	10,902	10,400	502

The Adequacy of Supplies

A comparison of demand with estimated supplies of crude oil and natural-gas liquids offered on two bases. Thus conclusions may be drawn reflecting the degree of conservatism of the individual reader.

The comparison in Table 2 shows that purely domestic supplies will be adequate to meet total needs without imports, and will still afford the nation a protective cushion of about 5 percent. But this comparison is unrealistic to the extent that there will be imports of both crude and products. Striking a comparison on this basis, gives Table 3.

It will be noted that the protective cushion ranges up to 2 million barrels daily, amounting to between 18 and 20 percent over requirements. The Petroleum Administration for Defense is now advocating for security reasons that reserve producing capacity be pushed to about 25 percent above total domestic demand, including imports. We do not feel that this level can be achieved without some major adjustments to the industry's drilling program. In fact, we doubt that the industry will be able to carry a margin of greater than approximately 20 percent over current demand.

There has been considerable study of production of synthetic fuels to supplement the availability of crude oil.

Repeated study and analysis of this problem is healthy. To advocate building a synthetic industry, however, is to select the synthetic route as preferable to the traditional means of increasing supplies. This is a decision which should be based on economic considerations. Differences in reports by committees, consultants, or the Bureau of Mines on this subject will not be discussed. But isn't the answer relatively clear? Men in petroleum are well-acquainted with synthetic-fuel production processes. Petroleum capital will build such plants as soon as the conviction has been reached that production of synthetic fuels affords a more attractive return on investment than alternate use of that capital in customary development. Thus economic considerations will determine when synthetic plants will, and should, be built.

No one knows when economic conditions may indicate that synthetic-plant production might be anticipated. In terms of total supply, there appears to be a healthy cushion of sufficient magnitude for the next 15 years so that any construction as of this date would be at tremendous social cost. Also, our estimates of future availability of crude oil and natural-gas liquids reflect economic pressures for increased supplies. If the government builds plants for producing synthetic fuels from shale, coal, or gas and thus competes with industry, this tends to reduce the private search for oil supplies from natural sources. If such plants are operated in competition with private industry and do not make money, then the total availability of oil is less than it would have been if the same amount of money had been spent for direct exploration. If these plants are not operated because they cannot operate at a profit, wastes are compounded to ridiculous amounts. And, to repeat, if they can be operated at a profit comparable with that earned from other sources of oil, oil men will build them.

Probable Crude Runs and Refinery Capacity

Total requirements of petroleum products will be supplied from several different sources. Imports of finished products, particularly heavy fuels, will continue to supply an important part of demand. Transfers from crude and natural-gas liquids will also supply an important segment of the total. After making these and other minor adjustments—such as losses, crude exports, and refined-product inventory changes—we find probable crude runs by years as shown in Table 4.

Let us assume that the ratio of crude runs to total capacity in 1967 will be approximately the levels maintained during recent years. This gives us a clue to the probable refining capacity of the industry. On this basis, total refinery capacity in the nation will be approximately 10,700,000 barrels. This will require an annual expansion of total refinery capacity of approximately 250,000 barrels. Certainly this presents no unusual challenge to the industry in the light of what it has achieved since 1946—our average building rate per annum from 1946 through 1951 having been 320,000 barrels per day. And, when considering total refinery building, it must be recognized that the industry will have to replace obsolete equipment as well as add new capacity. Estimated expenditures by refineries alone in 1952 will probably exceed $1 billion. There is no question that the industry will provide adequate refining capacity to meet market needs.

TABLE 3
Total Availability vs. Total Demand
(Figures in Thousands of Barrels Per Day)

YEAR	Total Estimated Supplies of Crude Oil and Natural-Gas Liquids from Domestic Production, Plus Imports	Total Demand, Including Exports Minus Imports of Finished Products	Estimated Margin of Total Supply Over Total Demand
1950	7,610	6,449	1,161
1951	8,028	7,114	914
1955	9,492	8,123	1,369
1960	10,830	8,928	1,902
1965	11,652	9,637	2,015
1967	11,837	9,918	1,919

Refinery Construction Developments

Interesting new developments will appear in the construction of new refineries. Factors determining the economics of refinery location are changing. Technological progress of fuel reduction is resulting in higher yields of light products susceptible to pipe-line movement and in lower yields of residual fuels not susceptible to low-cost transport movement. This changed pattern of yields, and the ICC limitation on earnings on crude-oil pipe-line investment to 8 percent and the permissible rate of earnings of 10 percent on product pipe lines, are important factors in determining new refinery locations. Inasmuch as new crude producing areas must be connected to future markets, there are sound reasons for anticipating a greater dispersal of refineries—which this offers the advantage of decentralization of military targets—a greater dependence upon product pipe lines, and a reduced relative dependence upon crude-oil pipe lines.

TABLE 4
Estimated Crude Runs Required
(Figures in Thousands of Barrels Per Day)

1950	5,739
1951	6,494
1955	7,253
1960	7,878
1965	8,503
1967	8,763

Increased quantities of crude oil and natural-gas liquids must be brought to the refinery, and the finished products must be moved from the refinery to the market. This means that transportation facilities will be expanded. Crude-oil pipe lines will be built from new sources of crude to present refinery centers, and to new refinery centers; whereas new product pipe lines will be built from new refinery centers into markets which are presently served by pipe lines, and into markets which are not today considered sufficiently concentrated to warrant expenditures for such facilities.

Purely Statistical Basis

We cannot go into the details of probable future pipe-line construction from individual points of origin to individual destinations. Nor can the economic pressures which may come into existence be forecast with sufficient accuracy at this time to merit individual-project conclusions. This problem, therefore, has been approached purely on a statistical basis. It would appear that crude-oil and products trunk-line traffic will increase by some 400 billion barrel-miles. This means that, between now and 1967, the industry will build a net increase to its present pipe-line system equal to approximately half of present carrying capacity.

Another substantial consideration which needs to be recognized in the transportation factor is that the carrying capacity of ocean tankers will have to be increased. Adjustments of the carrying capacity of barges, tank cars, and truck transports will be made on a regular annual basis as may be needed by the market.

Thus our review of the probable 15-year future leads us to certain basic conclusions:

1) The future supply of crude oil and natural-gas liquids will be adequate to meet the needs of a greatly expanded market. Nevertheless, the demand for a larger backlog of producing capacity will result in greater and greater exploratory effort.

2) Even though many have considered that the postwar refinery building programs were of a catching-up nature, it now appears that building at almost the average rate achieved since 1946 will be normal expectancy for the future.

3) Adjustments, changes, and constant expansion of transportation facilities will be needed in the future.

This analysis affords confidence that the industry should be able to continue to do the job which it has always achieved, viz, supplying all the oil needed. "Growth" is perhaps the one

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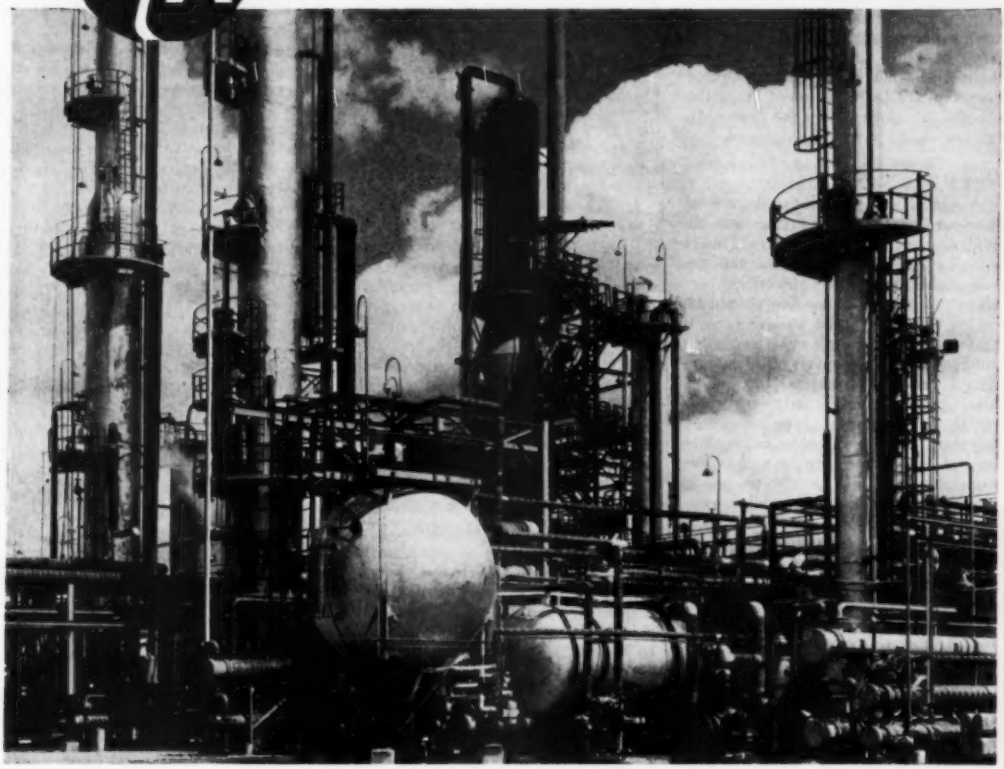

At Edmonton, Alberta, The British American Oil Company Limited has recently put into service a complete new refinery. Intended to handle production from Canada's great western oil fields, this new British American installation incorporates the most modern developments in refining technology. Like other leading refiners everywhere, British American at Edmonton relies on Petreco for desalting.

The Petreco desalter illustrated above desalts 5200 barrels per day of Redwater crude, with salt removals ranging from 94% to 96%. The electrosphere is one of Petreco's new high-efficiency, high-throughput spheres, eleven feet in diameter.

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word which best characterizes the future of our industry.

Major Economic Considerations

In the conduct of our study many economic uncertainties had to be resolved by assumptions. The validity of the forecasts depends upon the accuracy of our judgment. These problems and our conclusions regarding them are listed below. If subsequent events prove to be different from the conclusions shown, then the prognostications would have to be changed.

Monetary Stability

Assumed was a greater degree of monetary stability than has been in evidence in the past five years. This is an essential requirement to the accomplishment of the objectives previously discussed. Attention should be called to the fact that we are now in that phase of economic evolution when confiscation of property is reaching into investment in capital tools. Factors: a) Depreciation allowances for profit determination for income-tax purposes are inadequate to replace capital tools now in use. b) The understatement of depreciation results automatically in a corresponding overstatement of reported earnings. c) Reported earnings are subject to graduated income-tax payments.

Hence we are actually paying an income tax every year on a part of the capital invested in fixed plant facilities. Therefore, we are in a period of capital-tools confiscation.

Obviously expansion cannot be built soundly upon such a foundation. If this industry and other industries in this country are to achieve the growth needed to meet the requirements of a greater population and defense objectives, it will be necessary that a certain stability of the purchasing power of the dollar be achieved.

Financial Requirements

Most people look at an industry facing a substantial market expansion with considerable optimism. This is as it should be, but there is a problem which must be recognized. In petroleum, frequently expansion capital must be expended from two to probably six years ahead of the period of actual need. That is why there is truth in a tendency recently expressed—that the greater our sales, the poorer will be our cash position. Petroleum is a heavy capital-requirement industry. Its cash is frequently drained off to provide expansion required in the future.

Very few people, either in or outside the industry, realize the magnitude of capital requirements which will have to be met to build for a future market of the size discussed. No one knows what the actual total investment will be. The best anyone can do is to approximate. Our approximations resulted in a staggering concept of future capital requirements. We believe that total future expenditures for exploration and development of necessary reserves, for transportation facilities, and for refining and distribution needs will average approximately $5 billion per year. In fact, we are looking at a $75-billion program, this based upon the 1952 purchasing power of the dollar. If inflation continues, the amount will be correspondingly increased.

It has been assumed that the industry would finance this growth, but it cannot be financed from reserves and retained earnings. However, it would be well for all members of the industry to recognize that financing industry expansion is one of our greatest future responsibilities. It is even more vital that people outside the industry appreciate the essentiality of the profit incentive, as well as the inescapable necessity of plowing back a part of earnings, if we are to continue to grow.

Price Freedom

As to future price regulation, it was recognized that most of our historical pattern had been established when the economy was not subject to governmental price ceilings. We know also that prolonged price regulation leads to rigidities in an economy, and this inevitably retards growth. Hence we assumed that present price regulations as applicable to petroleum would not prevail for much of the 15 years under review.

This appears to be a logical assumption, because: a) supplies are considerably in excess of present rate of consumption; b) supplies are susceptible to substantial expansion both from domestic and foreign sources; c) the geographical distribution of supplies and the production rate of particular products are often adversely affected by insensitive price ceilings; d) price ceilings do not recognize growth requirements; e) a vast proportion of petroleum is now being sold at less than ceiling prices; and, f) the potentiality of increased foreign competition is ever-present.

In fact, there is no reason why price controls on petroleum could not be removed right now.

Highway Limitations

The data projected on cars in use and consumption per car cannot be achieved on the basis of present highway capacity. This economy is built to a large extent on an unusual degree of freedom of movement and transport via highways. It is obvious that many new highways must be built; many of the present ones will have to be improved and modernized. Estimated expenditures for highway construction in 1953 range between $2.7 and 3 billion.

Such new transportation arteries as are constructed will have to be engineered with the same degree of skill and planning as that applied to private ventures. In fact, both the petroleum and automotive industries may find it desirable to establish a group of expert highway engineers to function in an advisory capacity to insure efficiency of highway planning, construction, and financing.

The American public will pay a fair cost for making these additional facilities available. This is adequately demonstrated by the financial success of turnpikes. Therefore, as a basic premise underlying our work, it has been assumed that funds made available for highway construction will be used almost exclusively for that purpose, and that they will be wisely expended.

Industry Know-How

Money alone will not insure the growth needed. Money must be associated with industry problem-solving know-how. This presents a two-horned dilemma: a) broadening the training of more promising young men who will have to supervise the wider investments incident to a growth industry; and, b) retaining the productivity of some of our most successful industry members after the tax laws of the country have eliminated the economic incentive for further work.

The assumption regarding the first of these two was easy to reach. Larger capital requirements will necessitate careful supervision. This means that present management will have to train a larger number of leaders to follow them. Many companies in the industry will select their more promising young men and shift them from position to position so as to provide them with the broad basis of training necessary to meet the leadership requirements of the future.

The second part of this problem is more difficult. Why should a skilled individual continue to strive for greater accomplishments when he is denied the fruits of his labor by tax laws? And yet we know that our economy must have the benefit of the productivity of this class. Hence we have assumed the continued active contribution of the most successful persons of our industry, even though we

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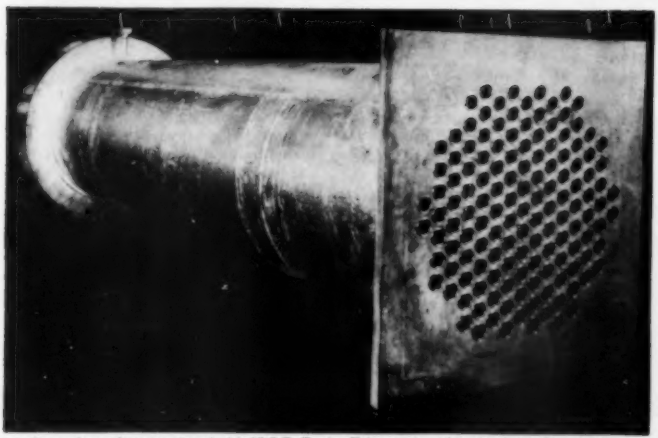

Ammonia condenser equipped with 2" O.D. Duplex Tubes steel outside, Admiralty Brass inside. Courtesy Ohmsteade Machine Works, Beaumont, Texas.

Refrigeration and Air Conditioning

Mechanical refrigeration and air conditioning have widely penetrated domestic, industrial, processing, chemical, and refining fields bringing many problems involving the handling of corrosive gases and liquids.

Freon and Methyl Chloride Refrigerants

For Freon or methyl chloride refrigerants that are in a dry condition, copper and copper-base alloys have proved to be most satisfactory from the standpoint of corrosion resistance and long life. On the cooling water side, arsenical Admiralty 30 stands up well in contact with low velocity sea water. On the fresh water side or where air is the cooling medium, copper is very satisfactory.

If there is a possibility of impingement corrosion because of high sea water velocities, Aluminum Brass 54 is superior to Admiralty 30. For extremely high sea water velocities one of the Cupro Nickel alloys is recommended.

Ammonia Refrigerant

Although dry ammonia gas is not corrosive to many metals and alloys, the corrosiveness of liquid or gaseous ammonia is greatly increased by the presence of water and oxygen or air.

Furthermore, ammonia combined with moisture and air is one of the most important factors contributing to stress corrosion cracking of many copper-base alloys. Stress corrosion cracking is a highly localized form of attack resulting in deep, narrow, penetrating cracks in stressed metals.

On the other hand, low carbon steel tubes are very resistant to both anhydrous and moist, liquid or gaseous ammonia. This explains their wide use in the construction of equipment handling ammonia. However, steel tubes and pipes are subject to corrosion from the brine, sea water or fresh water side. This shortcoming can easily be overcome through the use of Duplex Tubing, consisting of copper or copper-base alloy to the water side and low carbon steel to the ammonia side.

Duplex Tubes

Because of the above, Duplex tubes are finding wide application for ammonia refrigeration and for equipment producing ammonia and its compounds.

The most popular Duplex combinations are low carbon steel to the ammonia side, with Copper, Admiralty 30, or Red Brass 85 to circulating fresh water from rivers, lakes, ponds and wells. Where sea water is used for cooling purposes, 90-10 Cupro Nickel 510, 80-20 Cupro Nickel 520, 70-30 Cupro Nickel 531 (when available), Duronze IV 53 (Arsenical Aluminum Bronze), Aluminum Brass 54 and Admiralty are preferred to copper because of their greater corrosion resistance. When the velocity of the sea water is comparatively high, Cupro Nickel, Duronze IV and Aluminum Brass are preferred because of their greater resistance to impingement corrosion.

Duplex Tubes Improve Heat Transfer Characteristics

Experiments have shown that Duplex tubes made up of steel and copper or a copper-base alloy show superior heat transfer characteristics than straight steel tubes. Replacement of corroded steel tubes in ammonia condensers with steel/copper Duplex tubes has shown up to 25% reduction in power costs and require fewer tube cleanings. Also the use of Duplex has resulted in smaller size heat exchangers having the same total heat transfer as a larger size unit equipped with regular steel tubes.

It is especially important to have a tight joint in any ammonia system. A small leak may contaminate the cooling water or brine, thus accelerating corrosion of the copper or copper-base alloy.

Advantages of Duplex Tubes

Briefly the use of Duplex Tubing has many advantages:

(1) They do an excellent job where a dual corrosion problem is involved.

(2) Over a period of time, maintenance is considerably reduced.

(3) During periods of copper shortage, copper has been conserved or its use extended through the use of Duplex Tubing.

(4) Fine for untreated raw waters which are corrosive towards low carbon steels and stainless steels.

(5) Give greater corrosion resistance to treated waters.

(6) Frequently give markedly improved heat transfer characteristics.

(7) Can sometimes use a thinner wall Duplex tube than that of a regular tube.

Much information on Duplex tubes is given in Bridgeport's "Duplex Tubing Technical Bulletin No. 1950". Contact our nearest sales office for your tube requirements. (9083)

appreciate that their present economic incentives are grossly inadequate.

Labor Relations

The existence of monopoly places a deadening hand upon a company, an industry, and upon the total economy. One of the greatest satisfactions obtained during the years as an economist in the oil industry is the deep conviction that it is ruled by strong, keen competition. No objective student can study the behavior of this industry and reach any other conclusion. Strong competition must continue if we grow.

Management-labor relationships in our industry have traditionally been on a local or, at the widest, on a company basis. This has been conducive to progress, as evidenced by wages paid and employe benefits received as fine as are enjoyed in any industry. But efforts have been made to substitute bargaining on an industrywide basis. When industrywide negotiations come into existence, there is an ability to extort something from the public, whether this ability is exercised or not. Interruptions of operations because of labor-management disagreement when on an industrywide basis are in fact actions against the public.

There are competitive advantages incident to good labor-management relationships. Many in this industry are most anxious to see these advantages preserved both for labor and management. For this reason, it was assumed that the general pattern of labor relationship would not change.

Divorcement

Competition in the market over a period of many years has built an industry structure designed to meet best the needs of the market. In many cases individual firms have worked toward an integrated pattern for the purpose of supplementing the market organizational function of competition. This has resulted in various degrees of integration on the part of the vast majority of firms engaged in the petroleum industry.

Many organizations feel that the controversy involving integration does not touch them, but it does—either through ownership of transportation facilities, ownership of retail outlets, or ownership of an interest in more than one phase of the industry.

There is a suit pending which seeks to force a segregation of marketing from other phases of the industry. No one knows how far this effort will go. Many are confident that it is an effort to modify a structure which has been built as a result of competition in the industry. It pleads that additional curbs, or barriers, to the free flow of capital and effort be introduced with respect to the petroleum industry. Therefore, if atomization of this industry results from either judicial or legislative action, the forecast which has been presented is no longer valid. A chaotic condition not subject to the same economic laws which have existed in the past will be brought into being, and the premises upon which the forecasts were based no longer exist.

Reward to Capital

Claimants upon a productive capacity of an economy are usually listed as being labor, capital, government, and consumers. Labor receives a wage for its hire; capital receives an interest or dividend; the government receives its portion through taxes; and the consumer should receive his portion through greater real purchasing power of the dollar because of lower prices. But all laborers and all providers of capital are also consumers. Therefore, it is difficult to segregate the consumer's share of the output of goods and services. In reality, if this overlapping is recognized, one could say that the claimants are but three, viz, labor, capital owners, and government. Of these, government has received the greater rate of increase through higher and higher taxes. Labor has received an increasing proportion of gross national production. The providers of capital have received a diminishing proportion.

The essentiality of tremendous capital outlays on the part of this industry is easily seen. To achieve this growth is to the benefit of labor, government, and the providers of capital. A more equitable sharing of the fruits of production is a prerequisite to continued growth. Rewards to capital have passed the low level, and the future will see increased interest rates. Assumed therefore is that the capital-supplying segment of our society will be more adequately compensated in the future, and that a more well-balanced participation in gross national production among capital, labor, and government will come into being. It must, if the forecasts are to be realized.

Conclusion

There have been many collaborators in this study, both in the company and outside. We should like to express our appreciation to them for their invaluable assistance.

But, as to the forecast, there must be a word of caution. The industry alone cannot insure accomplishment of these objectives. If the American people will create an environment characterized by monetary stability, free prices, intelligent labor relationships, and a sound highway-development program, this industry will supply the petroleum needed to meet full requirements.

NOTE

Original presentation as a part of "Meeting Future Demand" by Mr. Boatwright and John E. Swearingen was before a session on supply and demand, Division of Refining, American Petroleum Institute, Chicago, November 10.

E. V. Murphree Gains High Research Award

Dr. Eger V. Murphree, president of Standard Oil Development Company, has been named as the 1953 recipient of the Industrial Research Institute Medal.

The medal has been awarded annually since 1945, to honor "outstanding accomplishment in leadership in or management of industrial research which contributes broadly to the development of industry or the public welfare."

Actual presentation of the award will be made next April at the annual meeting of the Institute, to be held at White Sulphur Springs, W. Va.

The Industrial Research Institute was organized in 1938 under the auspices of the National Research Council.

Dr. Murphree, who was appointed president of the Standard Oil Development Company in 1947, has guided his organization during a period of some of its most important discoveries.

Dr. Murphree

Among these contributions to the petroleum industry were new refining processes such as fluid catalytic cracking and fluid hydroforming. New products developed include highly specialized lubricating oils, petroleum chemicals and Butyl synthetic rubber.

Last year's recipient of the medal was Dr. Roy C. Newton, vice president in charge of research of Swift & Co.

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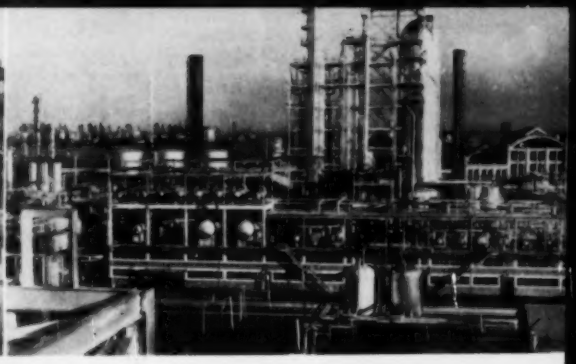
After the Battle

Debris of war littered the area near Anglo-Iranian Oil Company's refinery at Dunkirk, France, after the escape of the British expeditionary forces during World War II. The battle left the refinery gutted and looted of its machinery. Rebuilding of the plant began in 1948.



After the Building

A new oil refinery was dedicated at Dunkirk by Anglo-Iranian. Costing $50 million, it has a starting capacity of 40,000 barrels a day, which is expected to be increased later. Having four times the capacity of the plant destroyed by the Nazis, it is the only refinery in northern France.

[Who's Building What]

$10 Million Expansion Ended by Standard of Texas

Standard Oil Company of Texas has completed a $10 million refinery expansion program at its plant at El Paso, Texas. The new facilities include a synthetic crude unit and a Houdriflow catalytic cracking unit, each rated at 11,500 barrels a day and designed for equal quantities of fresh feed and recycle charge. Other major units are a 7555 barrel-a-day vacuum flash unit, a gas recovery plant and an alkylation plant capable of producing 1400 barrels of 100/130 octane aviation gasoline daily.

Catalytic Construction Company of Philadelphia engineered and constructed the plant.

Humble Oil Planning Sulfuric Acid Plant

Ground has been broken for the construction of a multimillion dollar sulfuric acid manufacturing plant on a site adjacent to Humble Oil and Refining Company's Baytown, Texas refinery by Humble and Consolidated Chemical Industries.

The exact cost of the project has not been divulged but Humble representatives have said that it will "cost several million." The plant is scheduled to be in operation within eight months and to be completed in a year's time.

The new construction will utilize as feed stock hydrogen sulfide recovered from processing of crude and certain acid sludges resulting from various refining process and formerly burned as fuels in Humble's Baytown refinery.

Two Units Scheduled For Antwerp Refinery

A 9000-barrel-a-day catalytic cracking unit and a 3000-barrel-a-day catalytic polymerization unit are scheduled to be completed in 1954 at the Antwerp refinery of Societe Industrielle Belge de Petroles.

Two-Year Modernization Completed By Trinidad

Completion of a catalytic cracking unit that marks the end of a two-year modernization program at its Pointe-a-Pierre, Trinidad refinery has been announced by Trinidad Leaseholds Limited.

In 1949, Trinidad Leaseholds, in conjunction with their consultants, the Universal Oil Products Company, worked out a scheme for the addition of new processes, the revamping of existing processes and extension and addition of utilities to service the proposed new equipment.

The process design of the new units and the revamped units was carried out by the Universal Products Company. Detailed engineering design, purchasing, shipment and erection for the new processes was done by Foster Wheeler Ltd., who were the main contractors for the job.

Other units in the modernization besides the catalytic cracking unit are a vacuum unit for catalytic cracking feed preparation, a gasoline treating unit and a gasoline return unit for handling the catalytic gasoline.

South Dakota Refinery Plan Backed by State's Jobbers

The South Dakota Independent Oil Men's Association recently threw its support behind a proposal that independent oil men of the State promote construction of a new refinery in eastern S. D. to process crude from the Williston Basin.

In a resolution, the association went on record as being "highly in favor" of the project and ready to lend its "full and active support" to the proposal. An association committee will be appointed to work with the refinery corporation when it is organized, and with the South Dakota Natural Resources Commission toward achieving construction of the new plant.

Creole Announces Plans For Doubling Capacity

Plans for the doubling of the present capacity of its largest refinery located at Amuay Bay in the Venezuela State of Falcon have been announced by Creole Petroleum Corporation.

The new installations, to cost $35 million, will permit the company to manufacture 91-octane aviation gasoline. The new plant will also refine some of the components of aviation gasoline of much higher potency.

When the new facilities are completed, Creole will refine nearly 200,000 barrels of crude daily at its two Venezuelan refineries. Design work already has begun and construction of the new Amuay plant is expected to begin late in 1953, with completion scheduled for the end of 1955.

Engineering for a new 10,000-barrel-a-day Fluid hydro-forming unit, to be included in Creole's Amuay Bay expansion, is to be handled by Standard Oil Development Company.

Sohio to Install New Platformer at Lima

The Standard Oil Company (Ohio) has announced that it will install a 12,000-barrel-a-day platforming unit at its Lima, Ohio refinery for the purpose of increasing the output of high-octane motor gasoline. The unit will also provide facilities for aviation gasoline, if needed.

Universal Oil Products is proceeding with design work on the company's letter of intent, but neither design nor construction contracts have been signed yet. Present plans call for breaking ground for the new unit next May, with completion scheduled for May, 1954.

Puerto Rican Bank Offers $3.3 Million Loan to Cosden

In connection with Cosden Petroleum Corporation's announced plans to establish a refinery near San Juan, Puerto Rico, The Puerto Rico Development Bank has offered to lend Cosden $3.3 million.

The offer came after Cosden had said that it could raise half of the $6.5 million needed for the investment. The bank has made the provisions, however, that the loan will be final only if the deal promises to be profitable and also

after assurances that the refinery will be able to get the necessary raw material and will be able to sell its production in the U. S. The offer will stand until December 15. If the deal is not completed by then, the loan offer will be canceled.

Cat Cracker To Go On Stream At AIOC's Llandarcy Refinery

Anglo-Iranian Oil Company's Llandarcy, Wales refinery is scheduled to have a new fluid catalytic cracking unit in operation by the end of this year. The new 10,000-barrel-a-day unit is part of major improvements made at the refinery since the end of the war. Llandarcy now has a thruput of 80,000 barrels a day compared with approximately 8000 barrels a day before the war.

A complete new 1300-barrel-a-day lubricating oil plant is also being constructed at the Welsh refinery and is due to be commissioned in mid-1953.

Other current projects listed by Anglo-Iranian are additional vacuum distillation equipment being constructed at Grangemouth, Scotland to prepare feed stock for a new 10,000 barrel-a-day fluid catalytic cracker due to go on stream by the end of the year, and a catalytic polymerization unit with a capacity of 2000 barrels a day being constructed at the same refinery. The cat-poly unit is expected to start operating in September 1953.

Shell Begins Operating New Sulfur Recovery Unit

A new unit which will recover up to 55 tons of sulfur daily from waste refinery gases has begun operating at the Houston plant of the Shell Chemical Corporation. The new sulfur recovery unit, certified by the government as a necessary defense project, was constructed by the Ralph M. Parson Company of Los Angeles. In the recovery process, hydrogen sulfide as contained in waste refinery gases will be catalytically converted to 99½ percent pure sulfur at an annual rate in excess of 13,000 tons.

Farmers Union Ups Laurel Refinery Capacity

The $4.5 million expansion of the Farmers Union Central Exchange refinery at Laurel, Mont., has been completed. New units include a 5000-barrel-a-day fluid catalytic cracker, a crude heater, a vacuum unit, a two-stage gas-concentration unit and a solid phosphoric acid polymerization unit.

Together with revamping work on the entire refinery to fit it for the new production pattern, the new facilities will boost crude-charge capacity to 12,500 barrels a day.

$8 Million Addition Planned By British American Oil

The British American Oil Company Limited has announced plans for an $8 million addition to the company's refinery at Clarkson, Ontario, 20 miles west of Toronto.

A catalytic cracking unit, a catalytic polymerization unit, gas concentration and other facilities will be installed.

Plant Expansion Behind Schedule

In a general report recently issued, Defense Production Administration has pointed out that one-third of oil refining facilities granted rapid tax amortization was "in place" as of June 30, 1952, with expansion running behind schedule. Contemplated expenditure was shown in the report as $1.3 billion, and "in place" total as $425 million.

In a later summary of the facilities expansion program, DPA announced it had approved 71 rapid tax write-off certificates for crude petroleum and natural gas extraction, refining and natural gasoline between June 20 and September 5. The value of the projects was estimated at $177,027,000, making this program fourth among all industries in dollar volume for the period covered. The agency said the rate of approvals for all industry dropped in August and September and pointed out that many programs are reaching their goals, thereby causing expansion to slow.

At the same time, DPA reported that most chemical expansion programs, including petrochemicals, are nearing their goals, with enough rapid tax write-off approvals issued to meet 29 of 43 program goals. New applications are continuing to come in for those programs not yet filled, DPA said, but the pace is definitely slower.

The largest write-off approval went to Standard Oil Company of California for expanding its refining facilities at El Segundo, Calif. To cost $27 million, Standard's expansion will include increasing basic refining facilities from 29,000 barrels a day to about 37,000 barrels a day and increasing alkylate output almost 1500 barrels a day.

Receiving one of the larger write-offs was the Gulf Oil Corporation, Port Arthur, Texas, for production of motor gasoline. Gulf received three certificates: $8 million, 65 percent; $2.1 million, 50 percent; and $2 million, 90 percent.

Other petroleum and related projects approved from mid-September to mid-October—with name of company, location of the project, type of facility, amount certified and percentage allowed—included:

Phillips Chemical Company—Moore County, Texas, nitric acid, $1.7 million, 45 percent.

Cities Service Oil Company—Crockett County, Texas, natural gasoline, $2.4 million, 65 percent.

Phillips Petroleum Company—Sweeney, Texas, petroleum refining, $5.6 million, 90 percent; $1.4 million, 50 percent.

Humble Oil and Refining Company—Baytown, Texas, motor gasoline, $4.8 million, 65 percent; $400,000, 50 percent.

Phillips Petroleum Company—Borger, Texas, petroleum refining, $371,000, 50 percent; $1.8 million, 90 percent.

Dow Chemical Company—Freeport, Texas, chemical production, $1.2 million, 45 percent.

H. W. Bass and Sons, Inc.—Live Oak County, Texas, natural gasoline, $3 million, 65 percent.

Goliad Corporation—Lavaca County, Texas, propane, iso-butane and natural gasoline, $114,875, 90 percent; $2.6 million, 40 percent.

Salt Lake Refining Company—Davis County, Utah, petroleum refining, $192,700, 65 percent; $11,000, 50 percent.

Sulfur Production Begun At New North Texas Plant

Production has been started on a new sulfur recovery unit in the Slaughter Field area of Texas, the North Texas-New Mexico division of Stanolind Oil and Gas Company has announced. The unit is being operated in conjunction with the Slaughter Gasoline plant, which began processing casinghead gas from the Slaughter Field three years ago. Owned jointly by eight separate companies, both the sulfur unit and the gasoline plant are being operated by Stanolind.

The unit is designed to process 8 MMcf. of hydrogen sulfide-bearing gas per day. From this amount of gas, the plant is designed to recover 48 tons of sulfur a day.

Okmulaee Expansion Completed By Phillips Petroleum

Marking the completion of its Okmulgee expansion and modernization program, Phillips Petroleum Company has dedicated a new T.C.C. air-lift catalytic cracking unit at its Okmulgee, Okla., refinery.

Included in the new facilities are an 8000-barrel-a-day cat cracker, a feed-preparation unit consisting of fired preheater, flash drum and vacuum still and a gas-concentration unit.

Kellogg Gets Contract For World's Largest Deasphalter

The Humble Oil and Refining Company has awarded The M. W. Kellogg Company the contract for the design and construction of a solvent deasphalting plant at Humble's Baytown, Texas, refinery. Said to have twice the capacity of any deasphalter heretofore designed, the plant will charge 28,000 barrels a day of vacuum reduced crude. Work will begin on the unit as early in 1953 as materials procurement will permit.

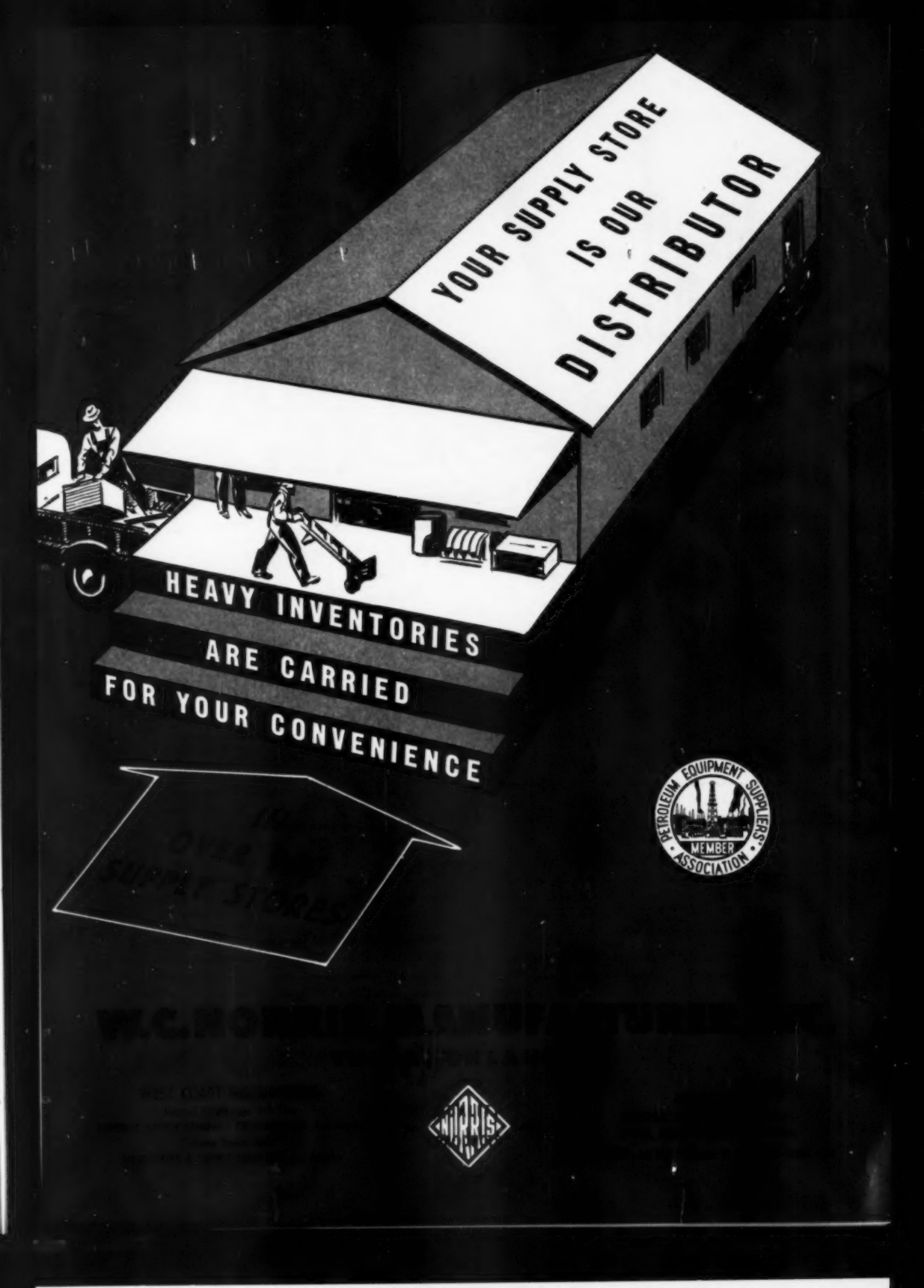
Humble Oil Plans to Add Cat-Poly Unit At Baytown

Construction of a new $4.8 million catalytic polymerization unit has been planned for early in 1953 at the Humble Oil and Refining Company's Baytown, Texas, plant. An additional $400,000 will be spent for utilities to serve the new unit.

The unit will be used to process some of the surplus coming as a result of a recent expansion of capacity of a catalytic cracking unit. The expanded cracker now processes 110,000 barrels of crude a day.

Maruzen Plans Capacity Hike And Cat Cracker in Japan

Plans have been announced by Maruzen Oil Company, Ltd., for an increase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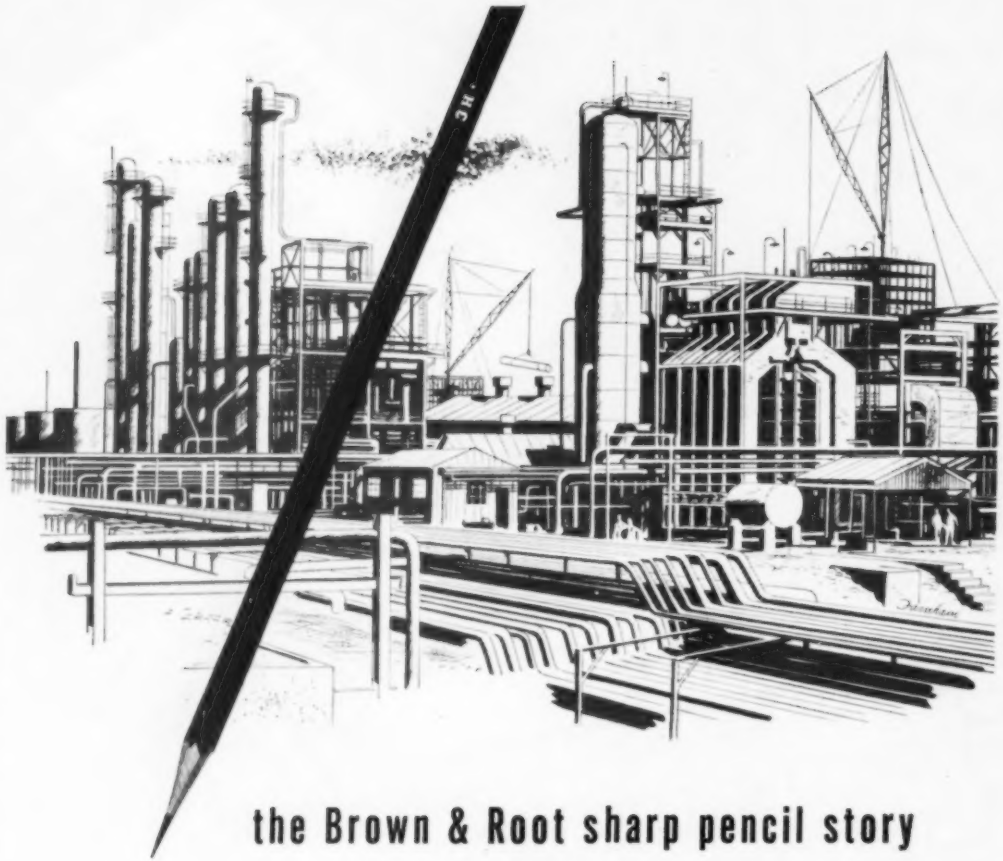

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AIOC Plan For Kwinana

Sketch of Anglo-Iranian Oil Company's 60,000 barrels daily refinery, work on which has started at Kwinana, near Fremantle, Western Australia. Planned for completion by the end of 1955, the new plant will cost an estimated $90 million and is expected to supply about 40 percent of Australia's then estimated petroleum requirements. Included in the five main units of the plant will be two atmospheric distillation units complete with stabilizers, solutizers and soda washers; a vacuum distillation unit, a catalytic cracking unit, a platforming unit and a hydrofining unit. Main contractors are The M. W. Kellogg Company and its British subsidiary, Kellogg International Corporation, in association with a group of British contractors headed by Costain-John Brown.

in crude-distillation capacity to 15,500 barrels a day and the construction of a 3000-barrel-a-day fluid catalytic cracking unit next year at its Shimotsu refinery in Wakayama Prefecture in Japan.

The catalytic cracking unit is to be completed by November, 1953. The refinery's present capacity is 11,500 barrels a day.

Two Companies Schedule Gasoline Plant for Pledger

Southern Production Company of Fort Worth, Texas, and Humble Oil and Refining Company will build a high-pressure, absorption-type gasoline plant in the Pledger field of Brazoria County. It will cost between $4.5 and $5 million. Stearns-Rogers has been awarded the contract to design and construct the plant.

To be located in the Pledger field approximately 11 miles from West Columbia, Texas, the plant will be operated by Southern Production, with Humble sharing 50-50 on the venture.

The plant is scheduled to be in operation by late 1953.

U. S., Puerto Rican Interests Plan New Refinery At Ponce

Plans for construction of a $20 million refinery in Ponce, Puerto Rico, has been announced by The Puerto Rican Oil Refining Company. Work is scheduled to begin within four months on the project, which will be financed by American and Puerto Rican interests. The plant will have a capacity of about 20,000 barrels a day with the oil coming from Saudi Arabia.

Kolker Plans Lindane Unit

Plans to build a $1 million unit for production of lindane at Houston have been announced by Kolker Chemical Works, Inc., division of Diamond Alkali Company.

Four Oil Concerns Plan Australia Refinery Expansion

Four oil companies have announced plans to spend nearly $184 million in the next four years expanding refinery capacity in Australia. When completed the program of expansion will make Australia virtually self-sufficient in refined oil products.

The four companies planning to step up refining production are the Anglo-Iranian Oil Company, Caltex Oil (Australia), Vacuum Oil Company and Shell Oil Company.

The biggest project is the $90 million refinery to be built by Anglo-Iranian at Kwinana on Cockburn Sound, just south of Fremantle in Western Australia.

The Shell Company is building a modern refinery on the shores of Corio Bay, near Geelong, in Port Philip Bay, Victoria State. Costing about $9 million, the new plant is expected to have a capacity of 1 MM tons by 1954. Its aim is a daily production of about 15,000 barrels of gasoline.

The Vacuum Oil Company will spend $29.3 million on extending its present plant at Altona, near Melbourne.

Caltex Oil Company will build a refinery with a yearly output of 1 MM tons of gasoline, kerosine, industrial oils and other products near Sydney. To cost $56.3 million, it will probably be completed by 1955.

Houdry's New Catalyst Unit In New Jersey Now Operating

Houdry Process Corporation has placed in operation a plant for the manufacture of Type 3 catalyst to be used in Houdriforming operations for up-grading naphthas to high octane gasoline, and the production of aromatics. Located at Paulsboro, N. J., the plant will initially produce this new catalyst for Houdriforming plants now under construction having a total capacity of approximately 25,000 barrels a day.

[Who's Building What]

Capacity to Be Hiked On Frontier Cat Cracker

Within the next few months, Frontier Refining Company will begin work to boost design capacity of an existing catalytic cracking unit at its Cheyenne, Wyo., plant from 2600 barrels to 6500 barrels a day. Cost of the expansion is estimated at $717,000, which would involve conversion of the present air compressor to a gas compressor, installation of two 300-psi. steam generators, a new blower, new regenerator grid, new cyclone for the generator and additional condensing equipment.

Universal Oil Products Company will handle design and engineering work. The government has approved for fast amortization 65 percent of the cost.

Also planned by the company is light-ends separation equipment at its polymerization unit.

Major Refinery Expansion Planned By Cities Service

A multi-million dollar program of expansion and modernization for its East Chicago, Ind. refinery has been announced by Cities Service Oil Company (Del.). It will include two major additions: a crude topping unit with capacity of over 30,000 barrels of charging stock a day and a catalytic reforming unit with a daily capacity of over 12,000 barrels. The existing delayed coking units will be increased to approximately double its present capacity.

A contract has been signed with Arthur G. McKee and Company for construction of the topping unit. Field construction of this unit is scheduled to begin early in 1935 with completion anticipated by the end of 1954.

Catalytic Construction Gets Contract for Fertilizer Unit

A contract has been awarded to Catalytic Construction Company by Allied Chemical and Dye Corporation, nitrogen division, for construction of a plant to make ammonia and urea fertilizers at Platte, Nebr. Actual construction cannot be started until the Federal Power Commission approves a contract with Northern Natural Gas Company for a gas supply for the plant. Girdler Corporation will probably design and erect the gas reforming and purification equipment.

Gasoline Plant Considered By Amerada Petroleum

Amerada Petroleum Corporation is considering building a natural gasoline and sulfur extraction plant in Williston Basin. The tentative plans estimate the cost at between $10 and $20 million but as yet are incomplete. Another company may join with Amerada in the project.

Bakelite Builds Phenol Plant

Bakelite Company, division of Union Carbide & Carbon Corporation, recently completed construction of a new plant at Marietta, Ohio. Annual production capacity of the new unit is expected to be 60 million pounds of phenol.

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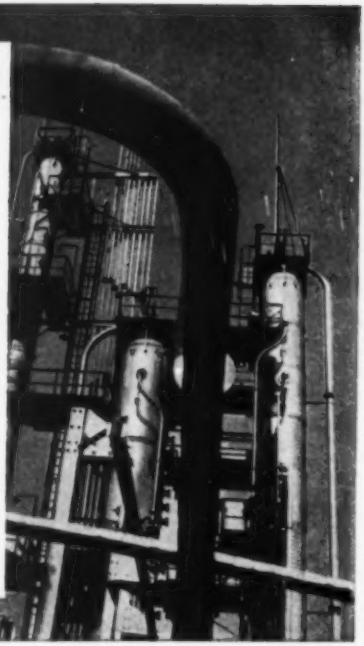

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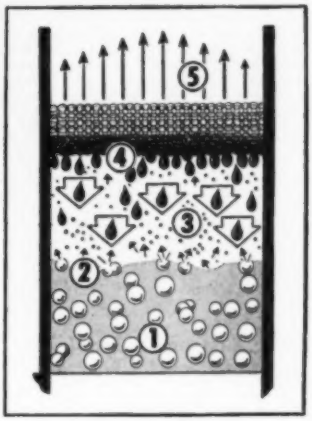

When a gas is generated in or passes through a liquid (1), it carries with it, as it bursts from the liquid surface (2), a fine spray of droplets of entrained liquid. These droplets are carried upward by the rising gas stream (3).

As the gas passes through the pad, the droplets impinge on the extensive wire surface (125 square feet of area per cubic foot of pad volume). The droplets coalesce on the wire surface to form large drops of liquid which break away (4) from the wire mesh and fall back against the gas stream. The gas (5) passes on, freed from liquid entrainment.

Availability

The pads, which are known as METEX Mist Eliminators, are made by Metal Textile Corporation, 633 East First Avenue, Roselle, N. J. A bulletin giving detailed information is available on request from the manufacturer.

(Adv.)

Before—
A hydrogenation plant in Western Germany Which was bombed into a "hopeless condition."

After—
The some hydrogenation plant after forces of reconstruction has had its postwar inning.

Germany's Hydrogenation Industry Today

Operations, which account for approximately one-third of the oil refined in western Germany have been converted from coal liquefaction to crude oil processing.

Peter W. Sherwood
Chemical Engineer
New York

PROGRESS has been considerable in the renascent German hydrogenation industry and good advance has been made in the reconstruction of West Germany's four plants, now converted to a crude oil basis.

These observations were made on the author's recent visit to Germany's hydrogenation plants, his first since shortly after World War II.

All of these plants had been severely damaged by heavy bombing attacks during the war. Following cessation of hostilities, resumption of operations was immobilized by a statutory provision against the production of synthetic fuels, for which the hydrogenation plants were originally designed. In result, his law has worked out to the advantage of Western Germany's indigenous petroleum supply, by stimulating drilling activities, which have found fair success.

Eventually, authorization was given for the use of the high-pressure hydrogenation process for upgrading crude oils and oil residues to gasoline and diesel fuel. First to be taken on stream was the plant of Union Rheinische Braunkohlen Kraftstoff at Wesseling which had entered an operating contract with Deutsche Shell. Shortly thereafter, in spring, 1949, Gelsenberg Benzin concluded a similar agreement with Deutsche Vacuum Oel A. G. and Esso A. G. for the supply of raw oils. Gelsenberg's plant was briefly halted during 1949 while the question of dismantling was brought up for final Allied decision. Since late 1949, Gelsenberg has maintained steady and growing production.

The more heavily damaged plants at Scholven and at Bottrop-Welheim have only during the past few months received the go-ahead for reconstruction work and they are scheduled to make a substantial contribution to Germany's supply of refined fuels. Scholven which had previously used some of its available stalls for the high-pressure refining of crude benzene, took up oil hydrogenation in May of this year. Its initial capacity of 200,000 metric tons/year Emsland oil is expected to be boosted to twice this value in less than a year. To achieve this goal, a catalytic cracker is to be installed and is to be coordinated with high-pressure operations by methods to be discussed below in greater detail.

Table 1. Output of Hydrogenation Plants and Their Share in Western Germany's Total Production[1]
(Quantities in metric tons per month)

PRODUCT	Topping Stage	Hydrogenation Stage	Total	% of W. Germany's Total Prod'n.
Gasoline	12,500	39,500	52,000	48.6
Diesel Fuel	17,000	0	17,000	26.6
LPG	0	3,500	3,500	87.9

The important advantage of the hydrogenation process over standard refining processes is, of course, its very much higher yield in automotive fuels. The consequent savings in oil imports turn out to be very significant, especially in the case of countries which are poor in foreign exchange media.

Table 1 illustrates the significant part of Germany's total production in refined fuels which was carried by the hydrogenation industry during the middle of 1951. This share is expected to increase somewhat, as the operations at Scholven and Bottrop-Wilheim make themselves felt. Eventually, however, this is expected to be overshadowed by increased refinery capacity now under construction.

More recent figures indicate that Gelsenberg and Wesseling refined 1,116,000 metric tons crude oil during the whole of 1951. This is roughly one-third of the thruput through Western Germany's entire 1951 refining capacity.

Resumption of operations could not have been effected as rapidly on a coal basis as has been found possible by adapting the hydrogenation plants to a crude oil feed. The heart of the hydrogenation process are the high-pressure stalls which have suffered relatively little from bombing damage due to the rugged construction of their components. Principal damage has been in the accessory handling areas, such as the centrifuges, coal paste preparation mills, and LTC furnaces for the recovery of heavy oils from the solid-rich centrifugal effluents. None of these plant parts are extensively required where substantially ash and bitumen-free oil is used as raw material.

Gelsenberg has been able to sidestep the problems created by the destruction of the gasifiers and water gas converters by shifting to coke-oven gas as its sole external source of hydrogen. This is made economically possible by the much lower hydrogen consumption in oil conversion as compared to coal hydrogenation. The coke-oven gas is fractionated in a Linde-Bronn low-temperature distillation unit. A secondary, but important result from this approach is the availability of methane in substantial amounts, which is piped to neighboring Huls for conversion to acetylene.

Principal reconstruction activities have had to be concentrated on low-pressure units which are essential to the hydrogenative conversion of heavy oils to refined fuels. The most critical problems were encountered in the distillation areas, in the rebuilding of pipe lines, and—above all—in the reconstruction of storage tanks.

Most important new construction were adequate topping facilities. There is, of course, little point in passing light oils through the expensive high-pressure stages. Instead, the crude oil, as delivered to the plant, is separated into straight-run gasoline, middle oil of boiling point up to 645 F., and heavy residues. The middle oil fraction may be taken through the vapor phase for conversion to gasoline, while the heavy residues are passed through the liquid phase for primary conversion to middle oils, which are subsequently hydrogenated in the vapor phase.

The solids-handling plants of the West were not equipped with adequate handling facilities for crude oil shipments and for their storage, and these have had to be provided.

In all, Gelsenberg reconstruction work has been estimated in excess of $7 million. This compares with a first investment cost of roughly ten times this figure during the original construction. (These figures are based on a conversion of 4.19DM (or RM) = $1.00. Because of the erratic behavior of German currency in recent years, and because of world-wide inflation, these cost figures are only comparative and have no absolute meaning in terms of dollars.)

Production Rate Progress

Progress in production rate has been rapid. From inception of operations in 1949, production at Gelsenberg rose to a monthly 25,000 tonnes (= metric tons) crude oil thruput in early 1950, and from there to 60,000 tonnes per month, the present legal limit. Gelsenberg has now raised its sights to roughly twice this capacity and expects to achieve this within a short time after approval is granted by Allied authorities.

Gelsenberg is now contemplating the erection of a catalytic cracking plant. Integration of this unit with hydrogenation operations will be discussed in more detail below. The use of a cracker has the advantage of materially reducing the load on the high-pressure stages. As a result, a given amount of high-pressure reactor volume can be more effectively utilized for higher thruput.

While oil hydrogenation has never previously been practiced in Western Germany, experience has been gained in commercial operations at Politz and, to a more limited extent, at Lutzkendorf, as well as in extensive laboratory and pilot plant work at Badische Anilin und Soda Fabrik, Ludwigshafen.

On the whole, the process of high-pressure oil hydrogenation (which is now being practiced in Germany) is presumed to be of more immediate interest to the American oil industry than the destructive hydrogenation of coal. This method can go a long way toward stretching existing oil resources and can eliminate local surplus of heavy and middle oils by their conversion to gasoline which has a readier market, and can absorb more freight charge than is possible for the lower-grade fractions. The process of oil hydrogenation in the vapor phase has, of course, been used at various times for upgrading various petroleum fractions at five United States refineries.[2] It calls for substantially lower investment costs and hydrogen consumption, and can indeed be carried out successfully at lower pressures than are feasible in the hydrogenation conversion of coal to synthetic liquid fuels.

At present, German hydrogenation plants operate on a competitive basis, i.e., without subsidy of any sort. It should be noted, however, that German gasoline prices are higher than in the United States, even before taxes. A direct comparison between two such divergent economies may therefore not be made.

Technical Aspects of Hydrogenation

The process which is currently being practiced in Western Germany's plants for the hydrogenation of oil is illustrated in Figure 1.[1] The data refer to a feed of Aramco crude.

The crude is first subjected to topping. The residues from this operation are joined by catalyst and by recycle oil from two sources: 1) Bottoms of the A-distillation step following the liquid phase, and 2) heavy oil letdown (i.e., the non-volatilized oils collected in the hot catchpot inside the reactor stalls).

The combined feed is boosted to reaction pressure and fed through regenerative heat exchangers and a gas-fired preheater to the converters. High-pressure hydrogen is admixed to the charge at a point preceding the preheater.

Primary hydrogenation takes place in a series of three or four liquid-phase converters. The reaction is highly exothermic and it is necessary to control the reaction temperature by injecting cold hydrogen at various points along the converters. In the plant conversion from coal to oil basis, it was expected at first that the much lower heat of reaction for the hydrogen-rich new material might cause the converter temperatures to drop below activity level. This fear has been found unjustified. Of course, the amount of hydrogen required for both reaction and cooling purposes has been considerably reduced.

The effluent from the converters is passed to a "hot catchpot," operated just below reaction temperature. The liquid product from this unit contains the catalyst as well as those components of the charge which have resisted conversion during the first pass. The bulk of this slurry (called the h.o.l.d.) is returned to the liquid phase converters for two reasons. Firstly, it is desired to subject the unconverted organic matter to second-pass conversion. Secondly, this recycling serves to maintain the concentration of catalyst in the converters at the desired high level (23-27 percent) while the catalyst make-up is only 1 percent.

A portion of the h.o.l.d is continuously withdrawn from the high-pressure system. This bleed serves to free the stalls of spent catalyst. The slurry is subjected to a low-temperature carbonization step for the recovery of its contained oils.

The overhead product from the hot catchpot is cooled by passage through the regenerative heat exchangers and through water coolers, and finally enters a high-pressure cold catchpot. The

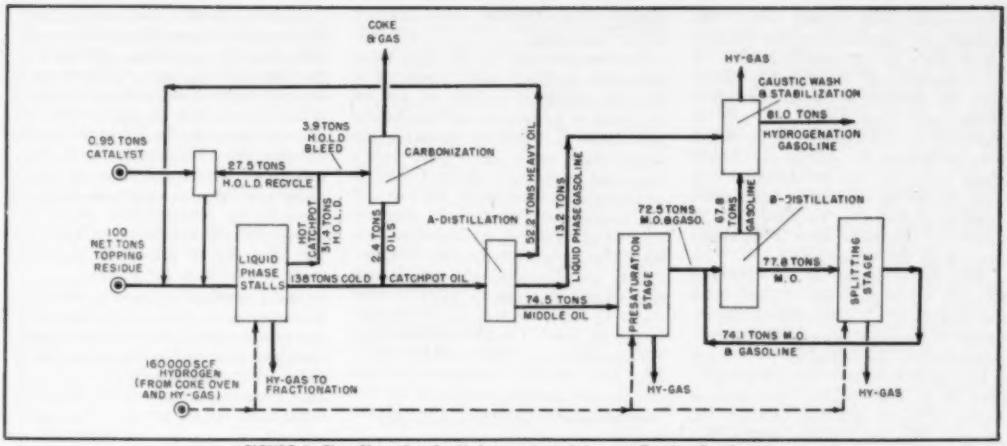

FIGURE 1. Flow Sheet for the Hydrogenation of Aramco Topping Residues.

vapor phase leaving this vessel is predominantly hydrogen. This gas is boosted to reaction pressure and is recycled to the converters. It should be noted that the low rate of gas formation in the hydrogenation of hydrogen-rich feeds obviates the need for oil-scrubbing the recycle gas which is frequently practiced in coal liquefaction operations.

The liquid product of the cold catchpot is released to atmospheric pressure in two stages. Gas released in the first stage consists primarily of hydrogen which is repressured and returned to the reaction stage. Gas released in the second stage is rich in hydrocarbons (Hy-gas) which are separated in a low-temperature fractionating plant.

The liquid leaving the final pressure-reducing stage goes to the liquid-phase distillation where separation is effected between the heavy oil (boiling above 645 F.) and middle oil. The bottoms of this "A"-distillation are recycled to the converters for secondary conversion. The overhead gasoline (F.P. 345 F.) is blended with straight-run and vapor phase gasolines for stabilization and sales. The intermediate middle oil is the chief make of the liquid phase and is forwarded for processing in the vapor phase.

A-middle oil is raised to reaction pressure and introduced into the vapor phase via heat exchangers in a manner not unlike that already described for the liquid phase. Sufficient high-pressure hydrogen is added preceding the heat exchangers to ensure complete volatilization of the oil.

In order to maintain the activity of the tungsten sulfide catalysts employed in the vapor phase at Gelsenberg, Wesseling, and Scholven, it is necessary to dope the feed with sulfur. This may be achieved by the addition of elemental sulfur or, preferably, of hydrogen sulfide which can be removed from the products and recycled (Gelsenberg converts surplus hydrogen sulfide to salable elemental sulfur by the partial combustion process).

For reasons to be discussed below, the vapor phase hydrogenation over tungsten sulfide catalysts takes place in two successive stages: presaturation over WS_2, and splitting over 10 percent WS_2 on a fuller's earth base. This mode of operation permits the use of lower temperatures than any other known effective condition. The advantage of low-temperature operation is the reduction of gas formation to a minimum.

The reactions occurring in the vapor phase are highly exothermic. In order to maintain the temperature gradient within the permissible temperature range of 35 F., the fixed-bed catalyst in these stages is arranged in separate layers inside the converters. Cooling hydrogen is injected between these layers.

The product leaving the converters passes through heat exchangers in which it gives up its sensible and latent heat to the incoming charge. Finally, the product is water-cooled and its two phases are separated in a high-pressure cold catchpot. The gas is recycled to the reactor stages. The liquid product is depressurized stage-wise and is finally fractionated into light products (mainly gasoline) and unconverted middle oil. This latter product is at present recycled to the splitting stage for the maximum production of gasoline.

In any operation directed at the decrease in molecular weight of hydrocarbons, there will be a disproportionation in hydrogen:carbon ratio. In substance, the original molecule is split into a saturated or near-saturated fragment of high hydrogen content, and a residual fragment which—due to its low hydrogen content—is highly unsaturated and consequently very reactive. This latter fragment will tend to engage in progressive polymerization reactions which eventually lead to the formation of compounds of very high molecular weight, collectively referred to as "coke," which are completely refractory to further attempts at breakdown.

The objective of high-pressure hydrogenation is to provide a set of conditions in which the unstable molecular fragments are saturated at a velocity exceeding their speed of repolymerization. This is brought about by the application of hydrogen at high partial pressure in the presence of suitable catalysts.

Attempts were made during the 1920's to carry out the primary reactions (in the liquid phase) in the presence of a fixed-bed catalyst. This approach was defeated by the unsatisfactorily short catalyst life due to the deposition of high-molecular-weight compounds on the catalyst surface. It was therefore found necessary to employ an expendable catalyst in small concentration in the primary conversion, and several such catalysts are now available.

However, the low concentration and relatively weak activity of the liquid-phase catalysts do not permit careful guidance of the reaction progress in accordance with desired results. It is thus found that gasoline produced in the liquid phase has an unsatisfactorily low octane number. At the same time, an undue amount of lighter products is formed. If the liquid phase were directed at the predominant formation of gasoline (by high tempera-

tures and long contact time), the amount of byproduct gases formed would place an unbearable burden on the economics of the process. Moreover, the refining action of the liquid phase (with regard to S, N, and O-removal) is inadequate. It is, therefore, preferred to utilize the liquid phase only for the production of a feed which can be suitably after-processed to high-quality gasoline in high yields by operation over a fixed-bed catalyst in the vapor phase.

The vapor phase of all Western German hydrogenation plants, with the exception of Bottrop-Welheim, is operated in accordance with the two-stage process developed by the former I. G. Farbenindustrie. For the production of a high-quality gasoline, a highly efficient splitting catalyst (10 percent WS_2 on fuller's earth) was developed. This catalyst is, however, limited in its charge to feedstocks containing less than 5 mg/liter alkaline nitrogen and substantially no phenolic oxygen. Furthermore, the performance and catalyst life are adversely affected by the use of stocks which are too highly aromatic. It is therefore almost universal practice to precede the *splitting stage* with a *presaturation stage* in which the feed is refined and raised to a sufficient hydrogen content. For this step, both Gelsenberg and Wesseling employ a substantially pure tungsten disulfide catalyst, and operate at temperatures lower than those found in the splitting stage (whereby the reaction equilibrium shifts to favor naphthenic over aromatic products). Historically, the pure tungsten disulfide (presaturation) catalyst is the older of the two. It is not, however, capable of producing gasoline in the quality demanded by today's market. The two steps of presaturation and splitting are operationally well integrated and function almost as a single step.

Reaction Conditions and Catalysts

a) Liquid Phase

The liquid phase at both Gelsenberg and Wesseling is rated at 10,300 psi. This pressure is required for the satisfactory conversion of bituminous coals for which these plants were originally erected. In the processing of oil residues, lower pressures have proved adequate, and operation at 4400 psi has had commercial realization. Gelsenberg is now reported to operate at 8300 psi, somewhat below design, but sufficiently above minimum feasible conversion conditions to take advantage of the greater space velocity which is possible as the pressure is raised. Ultimately, this pressure is also dependent on the degree of crude reduction; i.e., a more completely reduced crude will call for higher pressures.

The temperature in the first three converters is 895 F. and is reduced in the last converter to 860 F. by the injection of additional cooling hydrogen. Care is taken to maintain the temperature some 50 degrees below this level in the hot catchpot. This is of importance because, in this piece of equipment, there collects a stagnant pool of oil which is no longer in intimate contact with hydrogen. The conditions are thus ideal for coke formation which can lead to trouble, especially if there are serious fluctuations in the oil level. The preferred method for counteracting this problem is to introduce cooling hydrogen through the conical bottom opening of the hot catchpot, and bubbling it through the h.o.l.d.

The catalyst activity and concentration influence the optimum operating pressure and temperature. The most active catalyst used commercially to date is a mixture of tin oxalate and amonium chloride which has been applied in the conversion of difficult raw materials (such as bituminous coals and pitches) at 4400 psi. For more amenable substances, such as oils (notably paraffinic oils of the Emsland type), a less expensive catalyst can be employed to advantage. Present practice in the operating Western German plants calls for the use of iron sulfate and caustic soda impregnated onto a carrier such as activated lignite semi-coke (which is obtained as the undesired byproduct of some coal gasification processes). The catalyst contains 5 percent ferrous sulfate and caustic soda in equivalent amounts. Rate of use is just below 1 percent (based on make-up oil residue).

For any given raw material, the permissible throughput is a function of the operating conditions, the desired degree of conversion and the rate at which refractory h.o.l.d. is recycled to the converters. At Gelsenberg, reduced crude is charged at the rate of .015 net tons per cubic foot reaction space per hour. This compares with a throughput of .02 reported for a slightly more paraffinic crude at 10,300 psi.[3] Becker[1] reports an h.o.l.d recycle rate of .0047 tons per cubic foot per hour for the Gelsenberg operation.

b) Vapor Phase

For reasons pointed out, the conversion of middle oils to gasoline over WS_2 catalysts (at 4400 psi) is carried out in two stages. The function of the first stage (presaturation) is to refine the feed, i.e., to remove the objectionable basic and phenolic oxygen, and to boost the degree of hydrogen saturation for optimum yields in the secondary (splitting) stage. Of the oils available at Western Germany's plants, the straight-run middle oil is usually adequate for immediate charging to the final splitting stage, while the middle oil produced in the liquid phase is relatively low in hydrogen content and must of necessity be subjected to the refining step. To remove basic nitrogen from the straight-run oil, it is often possible to substitute an acid wash for the presaturation stage. This approach is not, of course, adequate for all types of oil which might be made available to the plants.

Every attempt is made to maintain the amount of light oil formation in the presaturation stage at a minimum. Gasoline produced in this stage, while thoroughly refined, exhibits a low octane number due to its high degree of saturation. Furthermore, if a large amount of gasoline is permitted to form in the presaturation stage, it must be separated from the make in order to limit the amount of further breakdown into gaseous products in the final splitting stage. Ideal operation limits the amount of gas formation in the primary stage to roughly 2-3 percent of the carbon in the middle oil feed.

This control over gasoline and gas formation in the primary stage of the vapor phase is exerted by adjustment of temperature and thruput (which is on a once-through basis). A typical set of conditions calls for temperatures of 720-750 F. and a thruput of more than 75 pounds per cubic foot catalyst per hour. According to Becker, the present recycle hydrogen rate in the presaturation converters is only 27,000 cubic feet per net ton total oil feed. This quantity is remarkably low and is explained by the high hydrogen content exhibited by the raw material which is reflected in the middle oil produced in the liquid phase. By contrast, an aromatic raw material, such as creosote middle oil, must be fed to the presaturation stage with 90,000 cubic feet hydrogen per ton oil feed, with an additional cooling gas requirement of 61,000 cubic feet per ton.[3]

Information received on the present-day operation of the splitting stalls is only scant, but a good guess may be hazarded from past experience in this field. The catalyst is known to be 10 percent tungsten disulfide on a fuller's earth basis. Typical operating temperatures are in the range 750-790 F. at the normal conversion pressure of 4400 psi (partial pressure of hydrogen is roughly 90 percent). Conversion is about 60-70 percent per pass with a total thruput of 75-83 pounds oil per cubic foot catalyst per hour. The splitting stage, of course, carries the heaviest part of the vapor phase burden in that it receives middle oil

from three sources: directly from topping, presaturation, and splitting stage recycle. The conditions here reported refer to the production of motor fuel, which alone is authorized at Western Germany's plants. The process is known to be adaptable to the production of aviation-base gasoline by the use of more drastic conditions (higher temperatures, greater recycle ratios).

Performance in Oil Hydrogenation

a) Liquid Phase

The outstanding feature of high-pressure hydrogenation for oil processing is the very high attainable yield. Indeed, over-all yields of motor gasoline for both phases are on the order of 80 weight percent with only small coke formation (approximately 1 percent).

Most of the losses to hydrocarbon gas formation are in the liquid phase. Operating efforts are directed toward maintaining the production of gas and low-grade gasoline in this phase at a minimum. Nevertheless, at commercially feasible time-temperature conditions and recycle ratios, the yield of gasoline plus middle oil does not exceed 84-86 percent in the primary phase. Typical liquid phase yields are 86 weight percent middle oil plus gasoline and 12 weight percent hydrocarbon gases. Liquid-phase gas consists of some 25 percent methane, 15 percent ethane, the remainder being divided between propane and butane in approximately equal proportions. The C_4-fraction at this stage is almost entirely n-butane.

For similar operating conditions, these yield figures are influenced to only a minor extent by the type of crude or residuum being used (unless the residuum is derived from cracking operations or is highly reduced by topping). The hydrogen consumption, on the other hand, is greatly influenced by the nature of the feed. Typical requirements in the liquid-phase hydrogenation of topping residues are 1500 standard cubic feet per barrel residuum feed.

An interesting side light is the presence of highly condensed aromatics, such as coronene, in the cold catchpot products. These materials are precipitated in amounts varying from .01 to .1 percent, depending on the nature of the crude and the hydrogen content of the catchpot oil. It has been estimated that coronene itself is recoverable from the hydrogenation products of petroleum residues at the average rate of 25 tons per 100,000 tons oil.

The principal byproduct of the hydrogenation process is elemental sulfur. Aramco residues taken into the liquid-phase stalls in Western Germany's hydrogenation plants assay 2.6 percent sulfur, slightly more than 1.5 percent above the sulfur content of the German oils being processed. The entire input of this element eventually shows up as hydrogen sulfide, convertible to elemental sulfur by partial combustion.

Table 2. Yields Obtained in the Catalytic Cracking and Vapor Phase Hydrogenation of the Same Middle Oil

	Hydrogenation	Catalytic Cracking
Weight percent Gasoline to 375 F.	90	45
Weight percent Gas	10	12
Weight percent Coke	0	3
Weight percent Residual Oil	0	40

Table 3

Middle Oil Feed from:	Spec. Gravity of Gasoline	Octane No. (Clear) (Motor Method)
Paraffin	.680	45
Crude Oil, Mixed Base	.772	64
Crude Oil, Asphalt Base	.728	67
Bitum.-Coal High-Temp. Tar	.748	75

Table 4
Inspection of German Hydrogasoline

	[1]
Gravity at 15 C.	0.718
ASTM-Distillation:	
Volume Percent—75 C.	24.5
100 C.	40.0
E. P.	195 C.
Reid V. P. (100 F.).	
(a) Winter	10.7 psi.
(b) Summer	10.0 psi.
Evaporation Residue, mg/100 cc	1.6
Octane No. (M.M.)	70 (1.2 cc TEL/gal.
Copper Corrosion	negative
Sulfur Content, Weight Percent	0.03

b) Vapor Phase

The yield-saving features of the vapor phase are no less impressive than those of the liquid phase. Table 2, based on data by Free,[4] shows the striking increase in recovery of useful products which is possible by hydrogenation as compared to catalytic cracking. The same middle oil was used in both processes:

These data are conservative, and industrial yield data for vapor phase hydrogenation are as high as 93 percent gasoline.

Gasoline produced by high-pressure hydrogenation in the vapor phase are highly refined and stable. Regardless of feedstock, properties exhibited universally by such gasolines are as follows:[5]

(a) They require no treating except a caustic wash to insure passing the corrosion and doctor tests.

(b) They are high in color (+30), have virtually no gum, and are low in sulfur (less than .03 percent).

(c) They have normal distillation characteristics.

(d) They are highly susceptible to tetraethyl lead, resembling in this respect the most lead-susceptible straight-run gasolines.

Operating conditions in the vapor phase exert an important effect on the physical and engine performance characteristics of hydrogasolines. Even more significant, however, is the effect due to the nature of the feedstock. This influence is, to be sure, considerably less pronounced than in the liquid phase, but it is of importance nevertheless. Table 3, due to Pier,[6] illustrates the profound effect of the feedstock on the product of vapor phase hydrogenation under comparable operating conditions.

However, all of these hydrogasolines have in common their great lead susceptibility. The octane number of hydrogasoline now being produced at Gelsenberg can be boosted from 64 to 81 by the addition of 2.5 cc TEL per gallon. Actual gasoline output at the plants is of lower quality, since straight-run gasoline is blended with the hydrogenation make. Clear octane number of the blend is just short of 60.

Inspection of a gasoline produced by topping and hydrogenation of reduced crude in Western Germany's hydrogenation plants has been reported by Becker[1] and is shown in Table 4.

Versatility of Hydrogenation

Hydrogenation and cracking can be suitably combined to realize the inherent advantages of both processes. Such a scheme is now planned for at least two Western German installations (Gelsenberg and Scholven), and the general consensus sees the future of oil hydrogenation in such combination processes in which maximum utilization is made of expensive high-pressure space, while the high yields of the hydrogenation process are nearly retained.

Several basic approaches are possible. The liquid phase of hydrogenation serves to best advantage in restoring very heavy oils to higher hydrogen content, while the vapor phase is used for the treatment of middle oils (gas oil, diesel oil, etc.).

Thus, once-through thermal cracking of many stocks will yield some 50 percent of heavy fuel oil. This product can be upgraded in the liquid phase and subsequently recycled to the thermal cracker with results which equal those obtained with virgin crude. This combination boosts the output of valuable light products by a factor of nearly two over straight thermal cracking. At the same time, the plant thruput per unit volume of costly high-pressure space is nearly doubled over straight hydrogenation treatment.

Similarly, liquid-phase hydrogenation can serve to prepare a very heavy (i.e., hydrogen-poor) crude for thermal cracking. Gasoline yields achieved in this manner greatly exceed the per-

formance of simple thermal cracking. The advantages of this combination tend to disappear, however, as the hydrogen content of the crude increases.

Vapor-phase hydrogenation is advantageously combined with catalytic cracking. Table 2 shows that the gasoline yield in the high-pressure process is roughly twice that of the catalytic cracking operation in which the suitability of the middle oil for reprocessing is greatly limited. The product of catalytic cracking is, on the other hand, of higher quality. Operating with the same charge stock, one may look for an octane number differential of 10 points between the products of catalytic cracking and vapor-phase hydrogenation.

Good use is made of the characteristics of both processes involved by hydrogenating catalytic cracker gas oil (over presaturation catalyst) under conditions which keep new gasoline formation at a minimum. The rehydrogenated middle oil is then returned to the catalytic cracker. In this combination, the entire feedstock is converted to gasoline and, unavoidably, some gas. In addition, there will be the usual coke deposition on the cracking catalyst, which must be removed in the course of regeneration.

The important effect of the interposed hydrogenation stage is illustrated by operating data with different middle oils from the same stock.[4] It was found in this instance that the straight-run gas oil could be catalytically cracked with a gasoline yield of 39 weight percent. The cracked gas oil, depleted in hydrogen, on the other hand yielded a mere 12 percent gasoline upon recycling to the catalytic cracker. This could be boosted to 38 percent by rehydrogenating the cracked gas oil before returning it to the catalytic cracker.

In this combination, practically the entire gasoline output is eventually derived from the catalytic cracker. The quality of the product is found to be the same as in straight catalytic cracking. It might be noted that the refining action of the high-pressure presaturation stage has a favorable effect on the lead susceptibility of the product. Free[4] estimates the over-all yield of this combination process at 70-72 weight percent gasoline.

An alternate method would take the gas oil product of catalytic cracking and complete its conversion to gasoline entirely by high-pressure hydrogenation in the vapor phase. This approach is intermediate between the catalytic cracking-presaturation combination described in the preceding paragraphs, and straight hydrogenation as now practiced. Here, the catalytic cracker gas oil is rehydrogenated by presaturation and is finally processed in the splitting stage with middle oil recycle. The blended gasoline has an octane number of about 5-8 points below the product of straight catalytic cracking. Gasoline yield, on the other hand, is estimated to be as high as 79 weight percent for this combination process. Utilization of high-pressure space is less efficient than in the combination catalytic cracking-presaturation-catalytic cracking.

Table 5. Hydrogenation of Crude Oil Over Fixed-Bed Catalyst. According to New B.A.S.F. Process

Operating Conditions	Pressure 9,000 psi. Temperature 842 F. Thruput .035 tons per cubic ft. per hour Hydrogen Consumption approximately 12,000 scf per barrel
Performance Data	Gasoline Concentration in Make 55 Weight percent Gasoline Space-time yield .017 tons per cubic foot per hour New formation Gasoline .012 tons per cubic foot per hour Gas Formation 14 Weight percent (Based on gasoline plus gas prod.) Gasoline yield (in recycle operation) 86 weight percent (slightly above 100 volume percent). Octane Number (with 1.5 cc Tel per gal.) 74 sp. g. of gasoline .730 Up to 80 percent of gas formation is C_3 and C_4.

New German Developments

The emphasis on oil hydrogenation since the end of the war has led to the development of new catalytic high-pressure hydrogenation techniques which will take optimum advantage of the available high-pressure space for the current raw material.

According to recent information, even heavy oil (either in virgin crude or in liquid-phase product) may be processed over fixed-bed catalysts. Most of this work is only now coming out of the pilot plants of Badische Anilin und Sodafabrik (Ludwigshafen).

The catalysts are reported to be based on activated alumina-silica, containing specially prepared molybdenum and tungsten salts. While no further details are given on catalyst composition, it is noteworthy that earlier work had shown that vapor phase hydrogenation at pressures as high as 9000 psi could be carried out on fuller's earth catalysts, containing little or no tungsten.

Pier[7, 8] reports that he has been able to obtain 50 percent conversion to gasoline of a liquid phase product made up of equal parts middle oil and heavy oil, by single-pass hydrogenation over a fixed-bed catalyst at 855 F. and 9-10,000 psi. By recycling the heavy fractions over the fixed-bed catalyst, an over-all gasoline yield of 90 weight percent (107 volume percent) is reported. This approach thus eliminates heavy oil recycle to the less efficient primary liquid phase, and does away with two-stage operation in the secondary phase. Over-all utilization of high-pressure space is more effective than in present hydrogenation technique.

It should be noted that (with one exception), the vapor phase stalls in Western Germany's hydrogenation plants are built for operation at 4500 psi. Existing plants can therefore take only limited advantage of this important new development. The process is also applicable at the lower pressure. However, the consequent reduction in thruput over the fixed-bed catalyst cancels any capacity advantage which might be derived from the elimination of heavy oil recycle in the liquid phase.

A similar process has been studied for the direct hydrogenation of crude oils over fixed-bed catalysts, thus eliminating primary liquid-phase hydrogenation entirely. Pier[8] found it possible to operate successfully for several uninterrupted months with the low-ash and low-asphalt crudes currently available to Germany's hydrogenation plants. For oils of higher ash content, the use of suitable separating equipment or of guard reactors is envisioned. It is furthermore reported that ash can eventually be readily removed from the catalyst without impairing the latter's activity.

Table 5[8] illustrates performance of this new process with an Aramco crude:

Similar results are obtained for operation at 4-4500 psi. However, the space-time yield is substantially reduced, and again the process loses many of its space-saving features. A similar loss in output per unit volume applies if the feed is topped crude or topped liquid-phase product. As a result, it is usually more advantageous to operate with unreduced crude, thus giving the lighter fractions the benefit of the refining and upgrading action of the hydrogenation process.

These new single-stage processes for the high-pressure hydrogenation of crudes have some features which will unquestionably be attractive in the processing of many American oils. In many cases, this interesting approach will merit closer study for American refinery conditions.

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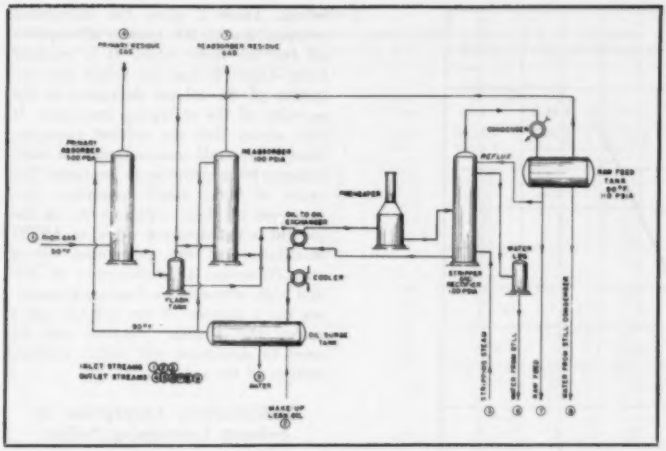

Figure 1. Simplified flow diagram of an absorption plant.

Process Design and Operation of Multicomponent Hydrocarbon Stripping

Important factors to be considered in the rich oil stripping and rectification systems of an absorption plant.

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THIS ARTICLE, based on a theoretical study, deals primarily with the important factors which affect the process design and operation of the rich oil stripping and rectification system of an absorption plant as follow:

1. The effect of the extent of stripping upon the recovery of various components as liquid in the raw feed.
2. The effect of the presence of solute in the solvent on the absorption of hydrocarbons in an absorber.
3. The effect of the stripper temperature on the process design of the stripping system.
4. The effect of the stripping steam rate on the process design of the stripping system.
5. The effect of the rectifier overhead vapor temperature control upon the
   a) absorption oil contamination in the raw feed.
   b) rectifier reflux requirement,
   c) rectifier condenser performance.
6. The effect of rich oil stabilization with respect to methane and ethane upon the ultimate recovery of propane in the raw product.

The results of the study are presented in Tables 1 to 6 and Figures 2 and 3.

The process flow diagram which is used as a basis for the theoretical study is shown in Figure 1. Briefly, the system consists of an absorption system and a stripping system. A primary absorber and a reabsorber comprise the absorption system. A stripper, a rectifier and their auxiliary heat exchange equipment comprise the stripping system.

The incoming gas rate to the system is assumed to be 10,000 pound moles per unit time at 300 psia and 90 F. The composition of the incoming gas is shown in Table 3. Three sets of calculations are made in which the pressure, temperature and oil circulation of the absorption system are kept constant, while the changes in the design basis of the stripping system are made as shown in Table A.

It will be observed from Figure 1 that under steady flow conditions, the incoming gas leaves the system through three outgoing streams, namely, the primary residue, the reabsorber residue and the raw feed. It is also noted that system absorption oil is a "recycle stream" and its composition is dependent upon the extent of stripping performed by the stripping system. The system absorption oil quality affects the quantity and the composition of all the outlet streams. Therefore, by calculating the recovery of various components as liquid in the raw feed for different design conditions of the stripping system, the effect of the extent of stripping can be determined.

Table A

Stripper Design Basis	Case A	Case B	Case C
Temperature, °F.	400	500	400
Pressure, psia.	120	120	120
Percent of n-Pentane contained in stripper liquid feed to be stripped	80	80	90

Table 1 presents the results showing the effect of the extent of stripping on the recovery of various components as liquid in the raw feed. It will be seen from Table 1 that the recovery of butane and heavier components is definitely dependent on the degree of stripping performed by the stripping system.

The over-all stripping of the rich oil is usually achieved by two steps, first, by preheating the rich oil to some high temperature and second, by injection of the stripping medium such as steam, in the stripper. Both of these steps require heat energy input to the system. If the sum of the heat energies consumed by the rich oil preheater and by the boiler in producing the quantity of the stripping medium is defined as the total stripping energy, this value can provide a quantitative measure of the extent of the stripping.

In Figure 2, the total stripping energy utilization is plotted against

Table 1
Recovery of Various Components in Raw Feed Liquid Due to Differences in Rich Oil Stripping
(Basis: 10,000 Pound Moles Per Unit Time Inlet Gas at 300 psia and 90 F.)

Component	PERCENT RECOVERY 80% N-C5 Stripped 400 F & 120 psia. Case A	80% N-C5 Stripped 500 F & 120 psia. Case B	90% N-C5 Stripped 400 F & 120 psia Case C
Methane	Trace	Trace	Trace
Ethane	3.2	3.2	3.2
Propane	42.8	42.8	42.8
i-Butane	93.7	93.7	94.1
n-Butane	97.8	97.9	98.3
i-Pentane	98.7	99.2	99.4
n-Pentane	98.6	99.2	99.3
Hexane	98.8	99.3	99.1
Heptane	98.5	99.3	99.0
i-Butane (+)	97.3	97.4	97.7
Raw Feed Volume, Gallons.	16,913	16,927	16,959

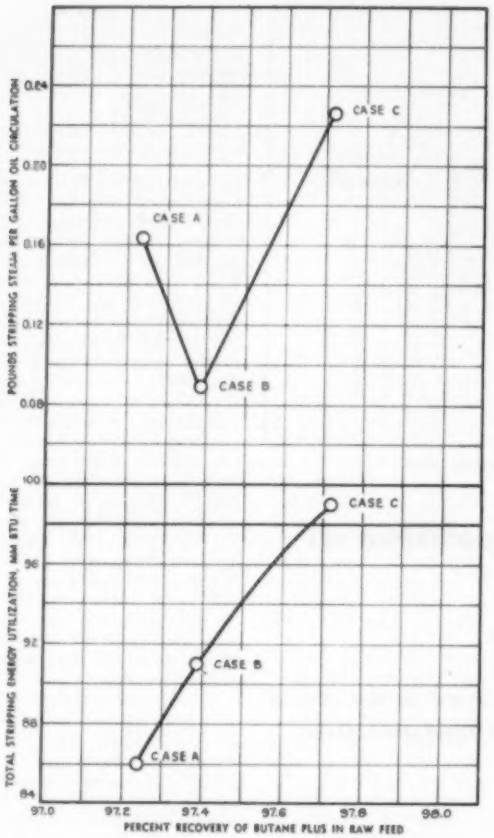

Figure 2. Curve I below: Butane plus recovery in raw feed vs. total stripping energy utilization. Curve II above: Butane plus recovery in raw feed vs. stripping steam rate.

the recovery of butane and heavier components in the raw feed. The resulting Curve I, shows that the recovery of butane and heavier components increases directly as the severity of stripping is increased. However, the rate of increase in the recovery of hydrocarbons is very small compared to the rate of increase in the total stripping energy. For an example, a comparison between Case A and C reveals that the hydrocarbon recovery increased only 0.5 percent by increasing the total stripping energy nearly 15 percent. On a quantitative basis, this represents an additional 47 gallons of the liquid product for an increase of 13 million Btu in the total stripping energy.

For a given process sequence and operating variables of the absorption and stripping systems, a correlation between total stripping energy utilization and the recovery of the hydrocarbons, similar to Curve I of Figure 2, can be prepared. By making an economic balance afterwards, the optimum stripping requirement for the given process flow can be determined.

Curve II of Figure 2, gives a relation between the stripping steam rate expressed as ratio of pounds of steam per gallon of lean oil circulation and the recovery of butane and heavier components as liquid in the raw feed. Since the injection of the stripping medium brings about only a portion of the over-all rich oil stripping, the rate of stripping medium alone does not furnish a true basis for a general correlation that can be used to determine the extent of rich oil stripping. For an example, a comparison between Case A and Case B from Curve II shows that even though the stripping steam rate for Case B is approximately half of that for Case A, the recovery of hydrocarbons for Case B is slightly greater than that for Case A.

Because of the differences in the rich oil stripping, the composition of the system absorption oil will be different. Table 2 gives the calculated composition of the system absorption oil for the three cases. It is evident from Table 2 that the solute concentration of the solvent decreases as the severity of the stripping increases. It also shows that the solvent contains, though in small amounts, all the components from propane to heptanes. Because of their small quantities, the presence of these components in the solvent is not detected when an ASTM distillation of the absorption oil is run. However, a combination of low and high temperature fractional analyses on a sample of the solvent taken under the system pressure can be used to determine the solute concentration of the solvent.

Hydrocarbon Absorption by Solvent Containing Solute

In the design calculations for an absorber, it is often assumed that the solvent is solute-free. This assumption does not introduce any serious error in calculating the lean oil circulation rate for the absorber. In actual practice, the production of a solute-free solvent by stripping the rich oil is rather uneconomical. Consequently, the system absorption oil does contain varying amounts of the solute. In order to determine the effectiveness of the stripping system, it is necessary to include the effect of the presence of solute in the solvent on absorption of hydrocarbons in the absorption system.

Table 3 presents the calculated results which show the effect of the presence of solute in the solvent upon the absorption of hydrocarbons by the primary absorber. A study of these results reveals that for the case of a

Table 2
System Absorption Oil Compositions Due to Differences in Rich Oil Stripping

	MOLE FRACTION			
Component	Absorption Oil New	80% N-C_5 Stripped 400 F & 120 psia. Absorption Oil Case A	80% N-C_5 Stripped 500 F & 120 psia. Absorption Oil Case B	90% N-C_5 Stripped 400 F & 120 psia. Absorption Oil Case C
Methane	.....	.....	.....	.....
Ethane	.....	.....	.....	.....
Propane	.....	0.00027	0.00047	0.00007
i-Butane	.....	0.00027	0.00029	0.00008
n-Butane	.....	0.00148	0.00140	0.00058
i-Pentane	.....	0.00103	0.00063	0.00046
n-Pentane	.....	0.00111	0.00064	0.00053
Hexane	.....	0.00098	0.00047	0.00063
Heptane	.....	0.00045	0.00037	0.00064
*Cut—450°.	0.48910	0.48603	0.48687	0.48748
*Cut—500°.	0.43270	0.43021	0.43097	0.43152
*Cut—550°.	0.07820	0.07777	0.07789	0.07801
	1.00000	1.00000	1.00000	1.00000
Solute Concentration	0.0	0.00599	0.00427	0.00299
Molecular Weight	192.1	191.4	191.6	191.8

* Represents 50 degrees apart normal boiling range cuts of absorption oil, e.g. cut—450° represents a cut with a normal boiling range of 425 F. to 475 F.

Table 3

Effect of Presence of Solute in Solvent on Absorption of Hydrocarbons in an Absorber

(Basis: 10,000 Lb. Moles/Time Absorber Feed at 300 psia and 90 F., 25.1 Gallons per mscf Oil Circulation)

Component	Absorber Inlet Feed Moles/T	ABSORPTION OIL			
		New	Case A	Case B	Case C
		Residue Moles/T	Residue Moles/T	Residue Moles/T	Residue Moles T
Methane	6,391.00	6,120.66	6,120.66	6,120.66	6,120.66
Ethane	1,231.00	920.66	920.66	920.66	920.66
Propane	1,604.00	487.62	488.80	489.34	487.87
i-Butane	145.00	4.78	5.37	5.42	4.96
n-Butane	474.00	4.74	7.28	7.15	5.75
i-Pentane	75.00	.....	0.76	0.46	0.38
n-Pentane	80.00	.....	0.52	0.36	0.30
Hexanes	16.00	.....	0.19	0.09	0.12
Heptanes	6.00	.....	0.07	0.03	0.05
Absorption Oil, Moles/T	10,000.00	7,538.46 0.28	7,544.22 0.28	7,544.17 0.28	7,540.75 0.28
i-Pentane (+), Moles/T	155.00	0.0	1.65	0.94	0.55
i-Pentane (+), Gal/T	2,187.0	0.0	23.0	13.0	12.0
i-Pentane (+), Mole Percent	1.55	0.0	0.023	0.013	0.011
i-Butane (+), Moles/T	774.0	9.52	14.30	13.51	11.56
i-Butane (+), Gals/T	9,642.0	116.0	177.0	166.0	142.0
i-Butane (+), Mole Percent	7.74	0.126	0.190	0.179	0.153
i-Butane (+) Loss over that of new oil, Gal./T	.....	0.0	61.0	50.0	30.0
i-Butane (+) Loss over that of new oil, Gal/mmscf	.....	.....	16.	13.	7.
Absorption Oil Loss, Gal/mmscf	.....	2.0	2.0	2.0	2.0
Absorption Oil, Mole Percent	.....	0.004	0.004	0.004	0.004

completely solute-free solvent (new absorption oil), the primary absorber recovers 100 percent of pentane and the heavier components. In contrast, for the Case A, B and C, the primary absorber residue streams show that a 100 percent absorption of pentane and heavier hydrocarbons is not realized. The presence of pentane and heavier components in the residue streams of Case A, B and C, is due to the presence of those components in the system absorption oil. (Refer to Table 2.) Also, the amount of pentane plus loss in the residue stream is different for each case. In general, as the sharpness of the rich oil stripping increases, the loss of pentane plus in the residue streams decreases.

The absorption of components lighter than pentane in an absorber is also affected if the solvent were to contain these components. A comparison of the residue streams for the new absorption oil and oils of Case A, B and C shows this effect.

Whenever the result of a low temperature fractional analysis of an absorber residue shows a large amount of heavy components, it is generally assumed that either the fractional analysis result is in error or the absorber lean oil circulation is not sufficient. As explained above, a third factor, which is also responsible for the presence of the heavy ends in the absorber residue is the concentration of these components in the system absorption oil. It is quite possible that when the rich oil is very poorly stripped, an appreciable amount of the heavy ends in the absorber residue can be due to the solute concentration of the system absorption oil.

It is pointed out that the absorber residue heavy components concentration as reported in the low temperature fractional analysis also includes that portion of the absorption oil which has been vaporized into the residue stream. The quantity of the absorption oil which will be carried as vapor in the residue, is dependent on the characteristic of the oil and the temperature and pressure of the lean gas leaving the absorber. Since the absorption oil is a multicomponent mixture, usually consisting of components with normal boiling points ranging from 400 to 550 F., the portion of the absorption oil carried as vapor in the residue streams consists mostly of the low boiling components of the oil.

As shown in Table 3, the loss of absorption oil in the residue stream at 300 psia and 96 F. is rather small. The calculated oil loss being about two gallons per Mmscf. The average molecular weight of the oil components in the residue stream is calculated to be 182, as compared to an average molecular weight of 192 for the new absorption oil.

Because of the limitation on the volume of the residue gas sample that can be handled by the low temperature fractionating column, the separation of heavy hydrocarbons and the vaporized absorption oil is generally not achieved with sufficient accuracy by the low temperature fractional analysis of the residue gas alone. It is the author's opinion that a "modified" charcoal adsorption method in conjunction with the low temperature fractional analysis can provide a means of separating pentanes plus hydrocarbons and the vaporized absorption oil in a residue stream.

In the "modified" charcoal adsorption method as suggested herein, a sufficient measured volume of the residue gas is to be passed through the activated charcoal at the plant, so that by glycerine distillation of charcoal carried to 525 F. end-point at the plant, approximately 15 cc of the hydrocarbon liquid are recovered at 32 F., the ice water bath temperature. About 10 cc of the liquid hydrocarbon at 32 F. are then transferred to a small stainless steel container by mercury displacement. A low temperature fractional analysis is then performed on the entire liquid sample from the stainless steel container by carrying it through hexanes. The heptanes plus residue of the liquid sample will represent mostly the vaporized absorption oil.

The effect of the stripper temperature on the process design of the stripping system is shown by the calculated results for the Case A and B given in Table 4. For the Case A, the stripper inlet rich oil temperature is maintained at 400 F. while for the Case B that temperature is maintained at 500 F. The pressure of the stripper in both the cases is held constant at 120 psia. Since the butane plus recoveries in the raw feed for the Case A and B differ only by 15 gallons in some 9000 gallons, the over-all hydrocarbon recovery by the stripping system of Case A and B can be regarded for all practical purposes as equal. The question of great importance then becomes, what are the advantages and

Table 4

Effect of Stripper Temperature Upon Process Design of Stripping System

(Basis: 10,000 lb moles per unit time inlet gas at 300 psia and 90 F.)

	Stripper Inlet T. 400 F. 50% n-Pentane Stripped Case A	Stripper Inlet T. 500 F. 50% n-Pentane Stripped Case B
Stripper Pressure, psia	120	120
Rich oil to stripper, Temp. F.	400	500
Stripper bottoms, Temp. F.	398[1]	498[1]
Rectifier Top Vapor, Temp. F.	142	142
Reflux accumulator, Temp., F.	90	90
Reflux accumulator, Pressure psia.	110	110
Reflux rate, Gal./T.	55,000	62,600
Stripping steam rate, Lbs./T.	24,560	13,250
Lbs. steam per gallon lean oil circulation	0.163	0.088
Water from still condenser, Lbs./T.	3,770	4,080
Water from still "water leg" Lbs./T.	15,300	4,460
[2]Water from lean oil surge tank, Lbs./T.	5,530	4,710
Butane plus recovery in raw feed, Gal./T.	9,376	9,391
Heat Exchange Equipment:		
Rich oil to lean oil exchanger heat load, MM Btu./T.	143.6	210.1
Rich oil preheater heat load, MM Btu./T.	56.6	75.1
Rectifier condenser heat load, MM Btu./T.	60.5	66.7
Lean oil water cooler heat load, MM Btu./T.	33.7	33.7
Stripping total energy utilization, MM Btu./T. (Preheater + stripping steam heat loads)	83.9	90.9
Rich oil to exchanger, Temp. F.	121	121
Rich oil to preheater, Temp., F.	330	415
Lean oil to water cooler	151	151

[1] Heat loss to the surroundings by radiation and convection not included.

[2] Due to absorption of stripping steam by absorption oil in the stripper.

disadvantages of operating a stripper at a high temperature level?

A comparison between Case A and B from Table 4 reveals that for a constant pressure, a change in the stripper temperature affects the stripping steam requirement, rectifier condenser heat load, rectifier reflux rate, rich oil preheater's heat duty, rich-oil to lean-oil exchanger's heat load and the quantity of stripping steam going into solution with the absorption oil.

In general, by increasing the stripper temperature, the stripping steam requirement is decreased to do the same over-all stripping. For an example, at 120 psia, by increasing the stripper temperature from 400 to 500 F., the stripping steam requirement is nearly halved.

Whenever good water supply for the steam plant is limited, a high temperature operation of the stripper provides a distinct advantage over a low temperature stripper operation. However, a reduction in the stripping steam quantity for the high temperature stripper operation, does not always represent a decrease in the total stripping energy, consisting of the energies consumed by the rich oil preheater and the steam plant. A larger percentage of absorption oil is vaporized when the rich oil is preheated to a higher temperature. Consequently, in the case of a higher temperature stripper operation, a slight increase in the total stripping energy results. From the total stripping energy point of view, therefore, by operating the stripper at a higher temperature does not provide any real advantage. To summarize, the high temperature stripper operation requires a larger rich oil preheater and a smaller steam plant, while the low temperature stripper operation requires a smaller rich oil preheater and a larger steam plant.

From the heat exchange equipment point of view, it is evident from Table 4 that the stripping system of Case B, representing the high temperature operation, possesses several disadvantages over that of the Case A representing the low temperature stripper operation.

For the Case B, more heat exchange surface is required for the rich oil preheater, rich-oil to lean-oil exchanger and the rectifier condenser than that for the Case A. Also, a larger size rectifier reflux pump is required for the Case B than that for the Case A.

When the stripping steam is passed through a stripper, a portion of it is absorbed by the absorption oil. For a given stripping-steam rate, the maximum quantity of steam that can dissolve in the oil is dependent upon the stripper bottom temperature and pressure and the quantity of absorption oil. For a constant system pressure, in the temperature range of 300 to 500 F., the solubility of steam in the absorption oil slightly decreases with an increase in the stripper temperature. For instance, by increasing the stripper temperature from 400 to 500 F. at 120 psia, the amount of steam dissolved in absorption oil is decreased by nearly 10 percent.

Table 5 presents the calculated results which show the effect of stripping steam rate upon the process design of the stripping system. For the Case C, the stripping steam rate is nearly 40 percent more than for the Case A. In both the cases, the rich oil temperature to the stripper is 400 F. at 120 psia.

Since a larger quantity of the stripping steam is used in Case C, its total stripping energy becomes greater than that for the Case A. The severity of over-all stripping for the Case C is enhanced and therefore, a higher recovery of hydrocarbons in the raw feed for the Case C is realized. However, the rate of increase in the hydrocarbon recovery is rather small compared to the rate of increase in the total stripping energy.

Because of the increase in the total stripping energy, the rectifier condenser heat load and the rectifier reflux requirement for the Case C are higher than that for the Case A.

In the operation of a rich oil stripping system equipped with a stripper and a rectifier, the separation between stripped absorption oil vapor and liquefiable hydrocarbons is usually achieved by controlling the temperature of the vapor leaving the top of the rectifier at a proper value with the rectifier reflux quantity. The temperature value at which the control point is to be set depends upon the inlet gas composition and the process sequence and operating variables of the absorption and stripping systems.

Based on calculations for the Case A, Table 6 was prepared to show the effect of the rectifier overhead vapor temperature controller setting on the absorption oil contamination in raw feed, the rectifier reflux requirement and the rectifier condenser performance.

The study of the results of Table 6 shows that whenever the rectifier overhead vapor temperature is controlled at a higher temperature than the proper value, a portion of absorption oil is distilled over into the raw feed. The quantity of absorption oil going into the raw feed increases as the difference between the set temperature and the required temperature increases.

The amount of absorption oil carried into the raw feed does not present a total economic loss because it finally shows up in the stabilized gasoline product. The difference in prices of the new absorption oil and the stabilized gasoline really determines the extent of financial loss, because for the amount of the absorption oil going

Table 5

Effect of Stripping Steam Rate Upon Process Design of Stripping System

(Basis: 10,000 lb moles per unit time inlet gas at 300 psia and 90 F.)

	80% n-Pentane Stripped Case A	90% n-Pentane Stripped Case C
Stripper Pressure, psia.	120	120
Rich Oil to Stripper, Temp., F.	400	400
Stripper Bottoms, Temp., F.	398[1]	397[1]
Rectifier Top Vapor, Temp., F.	142	142
Reflux Accumulator, Temp., F.	90	90
Reflux Accumulator Pressure, psia.	110	110
Reflux Rate, Gal./T.	55,000	99,500
Stripping Steam Rate, Lbs./T.	24,500	34,440
Lbs. Steam per Gallon Oil Circulation	0.163	0.227
Water from Still Condenser, Lbs./T.	3,770	4,600
Water from Still "Water Leg", Lbs./T.	15,260	24,430
[2]Water from Lean Oil Surge Tank, Lbs./T.	5,530	5,610
Butane Plus Recovery in Raw Feed, Gal./T.	9,376	9,423
Heat Exchange Equipment:		
Rich Oil to Lean Oil Exchanger Heat Load, MM, Btu./T.	148.6	149.2
Rich Oil Preheater Heat Load, MM Btu./T.	56.6	56.0
Rectifier Condenser Heat Load, MM, Btu./T.	69.5	71.9
Lean Oil Water Cooler Heat Load, MM, Btu./T.	33.7	33.9
Stripping Total Energy Utilization, MM, Btu./T. (Preheater + Stripping Steam Head Loads)	85.9	99.0
Rich Oil to Exchanger, Temp., F.	121	121
Rich Oil to Preheater, Temp. F.	330	320
Lean Oil to Water Cooler, Temp., F.	151	151

[1] Heat loss to the surroundings by radiation and convection not included.

[2] Due to absorption of stripping steam by absorption oil in the stripper.

Table 6

Effect of Rectifier Overhead Vapor Temperature Controller Setting on

(1) Absorption Oil Contamination in Raw Feed

(2) Rectifier Reflux Requirement

(3) Rectifier Condenser Performance

Rectifier Overhead Vapor Temperature Setting	Absorption Oil Contamination in Raw Feed	Raw Feed	Reflux	Condenser Heat Load	Water From Still Condenser	Water From Still "Water Leg"
Temperature, F.	Gals./Time	Gals./Time	Gals./Time	MM Btu./T	Lbs./Time	Lbs./Time
142	.....	16,677	55,030	60.5	3,770	15,260
200	52	16,729	31,790	60.8	11,710	7,320
250	300	16,975	16,980	61.9	19,030	.....

into the raw feed an equal amount will be required to be replaced by the plant make-up absorption oil.

The portion of the absorption oil carried into the raw feed consists mostly of the low boiling and low molecular weight components of the new absorption oil. Consequently, whenever some absorption oil is being distilled over in the raw feed, the molecular weight of the system absorption oil gradually increases. An excessive absorption oil make-up requirement and a gradual increase in the molecular weight of the system absorption oil are two symptoms which indicate that the rectifier overhead vapor temperature setting is too high.

Table 6 also points out that as the temperature setting of the rectifier overhead vapor is raised, the rectifier reflux requirement is decreased. It therefore, indicates that in order to operate a rectifier with a lower overhead vapor temperature than the existing one, it will require additional reflux pumping capacity.

The rectifier condenser heat load increases very slightly with an increase in the rectifier overhead temperature. However, for a constant cooling medium temperature, the log mean temperature difference of the condenser becomes greater as the rectifier overhead temperature is increased. Since the percentage increase in the log mean temperature difference due to a higher rectifier overhead temperature is considerably larger than that in the condenser heat load, the high rectifier overhead temperature operation requires lesser condensing surface than the lower temperature operation. Here again, in order to operate a rectifier with a lower overhead temperature than the existing one, it will require additional heat exchange surface for the rectifier condenser.

Rich Oil Stabilization

For a high propane recovery, 50 percent or more, as liquid in the raw product by absorption and stripping processes, one of the most important requisites is the removal of methane and ethane from the rich oil before the rich oil enters the final stripper and rectifier system. Figure 3, which has been prepared to illustrate this point, shows that as the quantity of ethane going into the raw product increases, the percentage of propane that can be retained as liquid in the raw feed decreases. Figure 3 was prepared for raw feed tank conditions of 110 psia and 90 F. However, a similar curve for any other pressure and temperature conditions of the raw feed tank can be prepared to show the same effect.

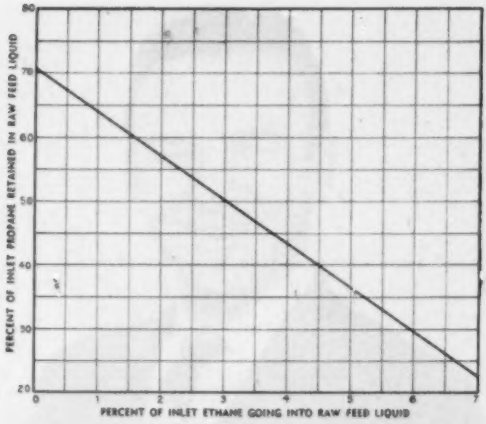

Figure 3. Effect of ethane contamination in raw feed on ultimate recovery of propane. Basis: raw feed tank at 110 psia and 90 F. 97.0 percent butanes recovery, 98.5 percent pentane (+) recovery.

The elimination of methane and ethane from the rich oil will require incorporation of some process step or steps which can be described under a general term of "rich oil stabilization." In high propane recovery absorption gasoline plants, process steps under several different names, such as "rich oil demethanizer," "rich oil deethanizer," "fractionating absorber," "propanizer-reabsorber," "two-still system," etc., are used which bring about the rich oil stabilization of varying degrees. With all the other variables unchanged, the incorporation of process steps which provide the most thorough rich oil stabilization will also provide the highest propane recovery as liquid in the raw feed.

Summary

The results of the study have shown that the energy consumed by the rich oil preheater and the stripping steam boiler which is defined as the total stripping energy, furnishes a quantitative measure to determine the extent of stripping. The optimum stripping energy requirement for any plant is dependent on the plant inlet gas composition, the process sequence and the operating variables. It can be determined by making an economic balance between the cost of stripping energy and the market value of the liquefiable hydrocarbons recovered.

An appreciable loss of pentanes and heavier constituents can occur in an absorber residue stream whenever the concentration of these components in the system lean oil becomes excessive due to the rich oil not being sufficiently stripped.

At a constant pressure, the higher temperature operation of the stripper requires less stripping steam quantity than the lower temperature operation to perform the same over-all stripping. However, from the total stripping energy utilization and the stripping system process equipment points of view, the higher temperature operation is not very advantageous. For a given inlet gas composition, process flow and operating variables, by making the necessary calculations, the optimum temperature for the stripper operation can be determined.

By increasing the stripping steam rate with other variables held constant, the degree of stripping is increased. However, beyond an optimum stripping steam rate, the rate of increase in products recovery is very small compared to the rate of increase in the stripping steam quantity.

Whenever the temperature controller setting on the rectifier overhead vapor is higher than the proper value, some of the lighter components of the absorption oil are distilled over into the raw product. A continuous carry-over of a portion of the lean oil into the raw product in this manner will result in an excessive make-up oil requirement and also, it will tend to increase the average molecular weight of the system lean oil.

For a stock tank propane recovery of 50 percent or more, the stabilization of the rich oil before it goes to the final stripping system becomes one of the important requirements of an absorption plant not using refrigeration.

ACKNOWLEDGMENT

The author wishes to thank Magnolia Petroleum Company for permission to publish this article.

Petroleum Refiner Editorial Director Dr. John J. McKetta and his AIChE Publications Award Plaque.

"Refiner" Editorial Director Wins AIChE Award for Best Paper

PRESENTATION OF the award for the best technical paper written by one of its members climaxed the A.I.Ch.E. South Texas Section's annual all-day Technical Section. The 1951-52 Award was presented to Dr. John J. McKetta, Jr., Editorial Director of the PETROLEUM REFINER, for his paper "Vapor-Liquid Equilibrium Constants in the Methane-Water and Ethane-Water Systems."

The 7th Annual Technical Section, attended by 725 chemical engineers from the Gulf Coast area, was held October 24 at the Rice Hotel, Houston, Texas. The meeting was divided into four sessions including two symposia, a general session, and a student session.

The symposium on fractionating trays reported the latest developments in the field including the Perforated, Kaskade, and Turbogrid trays. Beginning this symposium was a paper on bubble tray design.

The symposium on aromatics was introduced by an analysis of market patterns, followed by papers on the SO_2 process, Shell extractive distillation process, and Arosorb process for the recovery of aromatics. The general session included papers on the Wulf process, radioisotope applications, rapid reading, and tubular heater design.

The special session for students was devoted to the cultural aspects which an engineer should develop. Topics discussed include law; economics; music and drama; public speaking; politics and civic activities; and investment planning.

Sid Kirkpatrick, past president of AIChE, delivered the main address at the banquet. He pointed to the conflict in chemical engineering curricula of the fundamental science and unit operations concept in teaching.

Dr. McKetta's award paper, co-authored by Dr. O. L. Culbertson with Gulf Research and Development Corporation, presented the equilibrium constants for methane and water, and for ethane and water as calculated from experimental data for the two binary systems. These constants are for the two-phase systems for the temperature range of 100 to 340 F. and the pressure range of 200 to 10,000 psia.

Two of the papers presented at the meeting, the one on Turbogrid trays and the one on radioisotope applications, are appearing in this issue of PETROLEUM REFINER, as "Here's the Story on the New Turbogrid Tray" and "Check These Uses for Radioisotopes."

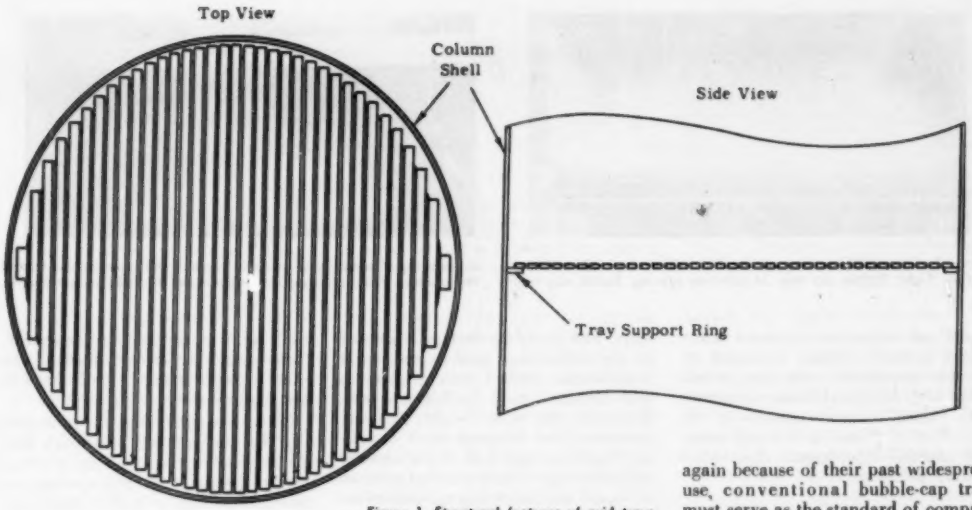

Figure 1. Structural features of grid trays.

Here's the Story About the New Turbogrid Distillation Trays

- **Higher Capacity**
- **Lower Cost**
- **Easier Maintenance**
- **Lower Pressure Drop**

Shell Development Company
Emeryville, Calif.

TURBOGRID trays,* a new type of vapor-liquid contacting tray for use in fractionation operations, are the result of an extensive research program on distillation equipment. The grid trays are very simple in construction, consisting merely of a flat grating extending uniformly over the entire column cross-section. The openings in the grating are parallel slots, of appropriate length, width and number. The trays contain no bubble-cap assemblies nor liquid downcomers. Grid trays are, thus, not in any sense a modification of conventional trays but a tray new in design and performance.

Performance of these trays has been confirmed in a wide variety of plant installations. Relative to well-designed bubble-cap trays, the grid trays have 20 to 100 percent greater capacity, approximately the same separation efficiency per foot of tower height and 40 to 80 percent lower pressure drop. The fabrication plus installation cost of grid trays is roughly 50 percent as much as for bubble-cap trays; important additional savings in their use result from lower column shell costs, lower maintenance costs, and ease of control and operation. By early 1953 about 50 grid tray columns will be in commercial service.

Distillation and adsorption columns represent a major capital investment in chemical industry as a whole and particularly in petroleum refining and processing. Because they are important as industrial equipment, improvement in their performance has been and continues to be the subject of considerable research. Inasmuch as bubble-cap trays have been used most extensively in fractionation equipment and have performed acceptably for the most part despite their limitations, they constitute the obvious starting point in such a research program. Furthermore, again because of their past widespread use, conventional bubble-cap trays must serve as the standard of comparison for any changes in tray design or in the development of new contacting trays.

The performance limitations of bubble-cap trays have been summarized in numerous technical and trade publications. In the initial phase of a research program to improve distillation equipment a large research investment was made toward overcoming these limitations. This resulted in an improved bubble-cap tray and a simpler, more reliable design method for them. The resultant standardized design, including cap and riser assembly, tray layout and downcomer construction, provided definite, but marginal, advantages over earlier designs.

However, it soon became apparent that further modifications produced little, if any, improvement for the reason that revisions yielding improvement in one aspect of tray performance were offset by poorer or unbalanced performance in other respects. That is, the best bubble-cap tray design proved to be a compromise of tray structural features — of downcomer area with liquid-vapor contact area, of uniform liquid and vapor distribution and good tray efficiency with low-pressure drop, and of downcomer height with theoretical plates per unit height of tower.

Consequently, the next step in the improvement of fractionation equipment appeared to be the development of a tray differing fundamentally from conventional contacting trays in the physical nature of the tray mechanics, in order to achieve improved tray performance, not by compromise, but by elimination of limitations. This improvement has been achieved in grid trays, which, by eliminating bubble caps and downcomers and by adopting a true countercurrent contacting of

* U. S. and foreign patents applied for.

Figure 2. Representative tray action. Left: Grid tray, 18-inch tray spacing. Right: Bubble cap tray, 24-inch tray spacing. Bubble cap tray is operating at same liquid rate and one-half the vapor volume rate of the grid tray. Tower cross-section of bubble cap tray is 60 percent greater.

liquid and vapor, has increased vapor-liquid contact volume, increased allowable superficial velocities, eliminated high frictional losses, dispensed with "dead" zones implicit in the cross-flow of phases in a round tower, and avoided troublesome downcomer settling problems.

Meet Design Capacity

A further advantage for grid trays developed from their simplicity of construction and made possible a more exact correlation and prediction of tray performance. Consequently, the performance of grid trays, despite their novelty, can be more confidently predicted than that of bubble-cap trays, where the multitude of possible structural variables, cap types and dimensions, cap layouts, downcomer and weir designs, to cite but a few, has rendered correlation of the considerable data at hand very difficult. This confidence has been substantiated by the industrial services in which grid trays are performing as predicted. No grid tray installation has failed to meet design capacity.

Figure 1 is a diagrammatic sketch of a grid tray. Construction is lighter and simpler than any other standard tray assembly now in use in the industry. The slots between the bars form the passageway for both vapor and liquid through the tray and vary in dimensions and number of slots per tray to meet the tray loading or application involved. Slot width can be varied over wide limits, to meet severe fouling problems, without affecting performance markedly.

The flow of vapor and liquid through a grid tray occurs as jets of vapor or liquid through the slots. The jets of either phase are random in time and location so that a uniform self-balanced flow of both phases over the column cross-section takes place. Because of the interference of the two phases in counter-flow through the same passageway, a substantial holdup of liquid on the tray occurs, but for equivalent separation, this holdup is considerably less than for bubble-cap trays. The liquid on the tray is aerated by the upflowing vapor to produce a liquid-vapor contact zone similar to that obtained on a bubble-cap tray. However, the zone height is lower because of the damping effect of falling liquid streams and of the absence of bubble caps. The horizontal motions of liquid and vapor are minimized because of the absence of cross-flow of liquid. Figure 2 illustrates representative grid tray and bubble-cap tray spray zones. Grid trays have a higher capacity for vapor flow than bubble-cap trays since all of the column cross-section is utilized and since the spray zone height and the pressure drop are less. They have a much higher capacity than bubble-cap trays for liquid flow since cross-flow liquid resistance is absent and downcomer settling is not a problem.

By varying the amount of tray open area, tray spacing, slot width, and other factors grid trays can be designed for optimum performance and minimum cost for any service. Wide flexibility in choice among efficiency, capacity, and pressure drop is available in the design, so that it is possible to obtain the economic optimum installation by using ultimate capacity but somewhat less efficient trays in one case, lower capacity but highly efficient trays in another case, or trays giving high capacity and minimum pressure drop per theoretical tray in still another case.

The performance of grid trays has been confirmed for 25 vapor-liquid systems, both hydrocarbon and non-hydrocarbon in experimental and plant towers, representing a pressure range from 5 psia to 300 psig, a vapor density range from 0.04 to 2.8 pounds per cubic foot, liquid-vapor density ratios from 10 to 1000, and vapor-liquid volume flow ratios from 10,000 to 5. Column diameters have ranged from 2 to 6 feet and towers as large as 10½ feet in diameter are under construction. The performance data which follow were obtained with a C_7-C_8 test system in a 5-foot diameter tower or with air-water-solute systems in a tower of 9 square feet cross-section. These data are fairly typical of the relative performance of grid trays in any type of service.

Relative capacity data for three grid tray designs installed at 18-inch tray spacing and for bubble-cap trays of normal design at 24-inch spacing are presented in Figure 3. The bubble-cap design contained 6-inch caps on a cross-flow pattern; the downcomer area was about 10 percent of the column cross-section. The three grid designs—intermediate, high, and ultimate capacity — illustrate the wide range of throughputs that can be handled in a given tower by varying the tray design. The ultimate capacity design gives from 50 to 100 percent more capacity than the bubble-cap trays tested, depending upon the liquid rate; the intermediate capacity design gives 5 to 25 percent more capacity. Tray efficiency and operating flexibility generally decrease as the capacity of grid trays is increased, consequently the optimum capacity design will depend upon the separation requirements.

Figure 4 shows relative capacity as a function of tray spacing, for the high capacity grid design and the bubble-cap tray design described in Figure 3. Conditions are at total reflux with the C_7-C_8 test system. In the range from 12 to 24-inch tray spacing, the grid design gives from 40 to 60 percent advantage in capacity, and, carried to an extreme, grid trays at 6-inch spacing give 85 percent of the capacity of the bubble-cap tray at 24-inch spacing.

Relative Efficiency Data

Figure 5 shows relative efficiency data as a function of tray spacing for the same trays and conditions described in Figure 4. The flow rates are at about 90 percent of capacity for both tray types. Both the bubble-cap and the grid tray design show a decrease in theoretical trays per foot of column height as tray spacing is increased. Grid trays at 12 to 18-inch spacing give more theoretical trays per foot than does the bubble-cap tray at 18 to 24-inch spacing and also give higher

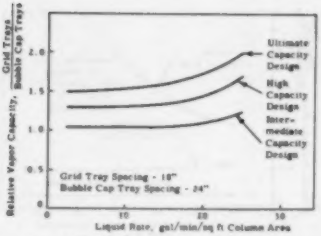

Figure 3. Relative capacity of grid trays.

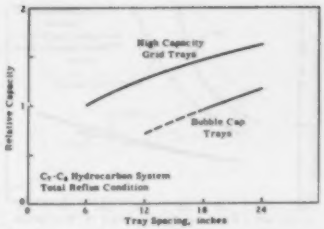

Figure 4. Capacity as function of tray spacing.

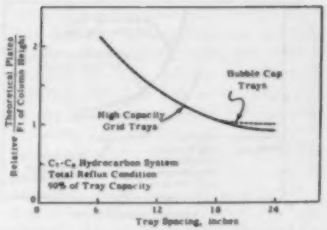

Figure 5. Separation efficiency as function of tray spacing.

capacity, as was seen in Figure 4. Therefore, in this design range both the diameter and height of the column are less if grid trays are used in place of bubble-cap trays. Considering both capacity and efficiency, the optimum tray spacing for grid trays generally falls in the range from 12 to 18 inches.

Figure 6 gives the relative efficiency of the same high capacity grid design at 12-inch tray spacing and the same bubble-cap tray design at 18-inch spacing, plotted as a function of bubble-cap tray capacity. The curves are average values for stripping, rectifying, and total reflux conditions. The bubble-cap tray gives a peak efficiency at about 70 percent of load point and gives lower efficiency on either side of this throughput. The grid tray gives about 35 percent more capacity than the bubble-cap tray and gives a continual increase in efficiency up to the load point. Above about 60 percent of grid tray load point (80 percent of bubble-cap tray capacity) the grid tray relative efficiency is higher than for the bubble-cap tray; below this capacity the grid tray efficiency is poorer. Grid trays generally are not recommended for installations which are expected to meet very low loading conditions, say from 25 to 50 percent of load point, since in this region the grid installation requires higher reflux ratios to attain the same separation obtained in bubble-cap trays. However, in the normal design region, from 60 to 100 percent of load point, grid trays give superior separation and permit a reduction in reflux ratio for a given separation as load point is approached. This gives a tower added flexibility near peak capacity conditions, beyond the natural capacity advantage of grid trays, an advantage that is very important in these times of expanding production.

A further illustration of performance is given in Figure 7 wherein the calculated column height and diameter requirements are shown for the separation of a butylenes mixture from catalytic cracking. The height-diameter curves are analogous to the usual theoretical plates-reflux curves for a given feed rate. At any point along the plates-reflux envelope, grid trays at 12-inch spacing lead to considerable savings in height and diameter relative to bubble-cap trays at either 18 or 24-inch spacing. This advantage is fairly typical for separations requiring a large number of theoretical plates, as for example propane-propylene or isonormal pentane towers.

Efficiency data have been obtained experimentally and from plant test runs for a number of hydrocarbon systems as well as for other vapor-liquid systems that simulate abnormal cases of stripping or absorbing at dilute concentrations. In all of these cases the efficiency of grid trays relative to bubble-cap trays was about the same as described in Figures 5, 6, and 7.

The extremely low pressure drop per theoretical tray obtained with grid trays, illustrated for typical conditions in Figure 8, is an important advantage in installations where pressure drop is critical, as in vacuum operations and heat pumping cycles. In the region of 60-100 percent of tray capacity, the high capacity grid design gives about one-third the ΔP/theoretical tray shown for bubble-cap trays at 18 or 24-inch tray spacing. Generally, the ultimate capacity grid design gives even lower pressure drop per theoretical tray than the high capacity grid design illustrated here. A pressure drop of less than 1 mm Hg per tray can be obtained in the ultimate capacity design while retaining good tray efficiency.

Figure 9 illustrates the components of pressure drop for a high-capacity grid design and for a bubble-cap tray having zero static submergence. The ratio of total pressure drop for the two types of trays is about 0.2 while the ratio of dry tray pressure drop is only about 0.06; this shows clearly that grid trays utilize the "useful" fraction of total pressure drop much more efficiently than do bubble-cap trays. The useful pressure drop is defined as the difference between the total pressure drop and the frictional loss, and for grid trays is approximately equal to the tray liquid holdup.

Where minimum tray holdup and residence time are critical, the low-pressure drop of the grid tray has a several-fold advantage over other types of trays in terms of theoretical plates per unit of liquid holdup or residence time. This feature is very advantageous in some chemical plant distillations.

Typical Turbogrid columns now in service in refineries and chemical plants are listed in Table 1. The services shown are very diversified, and many other services are being installed at this time. Plants under construction include columns in aromatics recovery, catalytic cracking gas recovery units, ammonia plants, crude units, natural gasoline plants, and various chemical plants. All of the towers listed in Table 1 are giving satisfactory performance. Where grid trays have replaced bubble-cap trays or packing in a column, capacity increases of 20 to 100 percent have been obtained, generally accompanied by the same or better separation per ft of column height.

The initial cost advantage of a grid tray installation in place of a bubble-cap tray installation varies with the nature of the installation. In each of the following situations, a different cost advantage for grid trays is encountered:

a) A new column plus new trays.
b) New trays in replacement service to provide increased capacity, where existing bubble-cap trays would be limiting.
c) New trays to replace corroded trays.

Table 2 shows relative cost data for the three cases. The saving using grid trays in Case (a) results from the

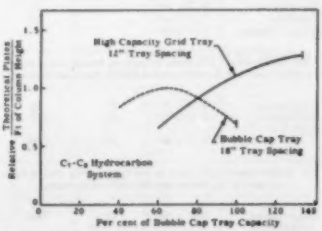
Relative Theoretical Plates, Ft of Column Height
High Capacity Grid Tray 12" Tray Spacing
Bubble Cap Tray 18" Tray Spacing
C5-C6 Hydrocarbon System
Per cent of Bubble Cap Tray Capacity

Figure 6. Separation efficiency as function of tray loading.

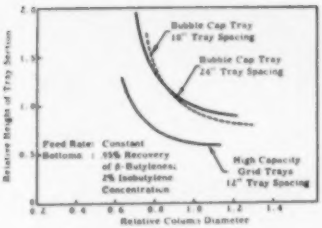

Figure 7. Calculated tower sizes iso-B-butylenes seperation.

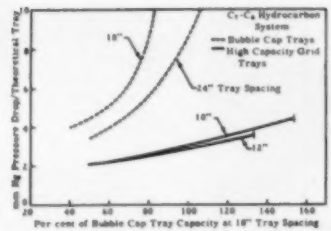

Figure 8. Pressure drop-efficiency comparison grid trays and bubble cap trays.

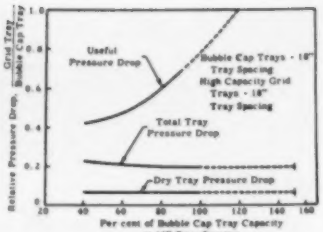

Figure 9. Pressure drop characteristics.

smaller tower volume (lower shell cost) and the lower tray cost. Savings are substantially greater if installed costs are considered, due to additional savings in foundation, insulation, painting, etc. In Case (b) the saving achieved by replacing existing trays with grid trays is related to the cost of a new column shell plus the saving on tray costs. In Case (c), where an increase in capacity or performance is not a factor, an advantage for grid trays still is present because of lower tray cost; further, a potential capacity advantage is available if needed. The savings in Cases (a) and (b) depend on the column loadings, inasmuch as the superiority of grid trays depends on the liquid loading; therefore, data are shown for selected operations, illustrating different load conditions. In all cases, a substantial saving results from using grid trays, and the saving is greatest where grid trays permit the use of an existing shell, which must otherwise be replaced or augmented with a parallel column.

The initial savings attained with grid tray installations tend to obscure the savings in maintenance and operation which result from their use. In many cases these savings are of greater significance than the initial capital savings. Plant experience has shown that corrosion and fouling problems are less severe with properly designed grid trays than with bubble-cap trays. Maintenance involves less time and lower cost since all parts of the tray are accessible and need not be disassembled for cleaning. The operating records of several towers (depropanizer, alcohol acid strippers, chlorinated hydrocarbons fractionators) show less fouling, longer tray life and shorter maintenance time, adding up to about 60 percent of maintenance cost recorded for bubble-cap trays in the same service.

A further advantage, in operation and control, occurs with grid trays in that they are more responsive to automatic control than are bubble-cap trays. They react more rapidly to changes in conditions because of low holdup and can accommodate momentary surges in flows more readily since they are less sensitive to changes in liquid load.

In the development of grid trays, all basic types of grid bars were investigated in order to develop the optimum tray design for different flow conditions. More than 40 tray layouts were investigated; these included trays containing round bars, flat bars, half round bars, angles, tees, and other geometric shapes. For most commercial installations it has been possible to standardize on one bar shape. Materials of construction, depending upon the service, have included carbon steel, alloy steels, copper, cast silicon-iron, Karbate, and Pyrex. Stamping of slots in thin gage alloy tray sections has led to further standardization and reduction in tray cost, and stamped slotted trays are being installed in nearly all current installations. For general service the stamped alloy trays cost less than do the carbon steel bar trays. Either the bar trays or the stamped trays are much lighter than conventional trays, which also simplifies tray support problems.

Considerable study has been given to the performance of trays perforated with round holes and installed with or without downcomers. Additionally, slotted grid trays with downcomers* have been studied quite extensively and this design has been installed for replacement service, for example, when removal of existing downcomers would have been troublesome. A complete relative performance picture for all of the tray types described is available to the Shell design groups. However, the slotted grid tray without downcomers generally is recommended over all other types, from the standpoint of performance, cost, fouling, and maintenance.

In summary, a new distillation tray design, grid trays without downcomers, has demonstrated decisive advantages relative to conventional trays in extended experimental studies and in more than 20 commercial installations. These advantages are: about 40 percent higher capacity for the same separation per foot of tower height, much lower pressure drop and tray holdup, lower installed column and tray cost, lower maintenance cost, greater accessibility, less tray fouling, longer tray life, and easier column control. For these trays design is flexible, performance is reliable, and fabrication is simple. Grid trays are no better than bubble-cap trays for service requiring a two- or three-fold range in feed rate nor are they recommended when a high holdup time is required to allow a chemical reaction to proceed to completion. They are being installed for all other distillation services which form the bulk, at least 80 percent of all refinery and chemical plant installations.

Table 1. Typical Turbogrid Installations Now in Service

- Deethanizers
- Debutanizers
- Topping Dephlegmator
- Depropanizers
- C_7-C_8 Fractionator
- Sour Water Stripper
- Chlorinated Hydrocarbons Fractionator
- Chlorohydrins Strippers
- Isopropyl and sec-Butyl Alcohol Acid Strippers
- Methyl Isobutyl Ketone Plant Columns
- Various Gas Scrubbers and Strippers (Removal of Acidics, SO_2, CO_2, etc.)

TABLE 2—Typical Cost Data
(Basis 1951-52 Conditions)

Type of Service	Size of Grid Tray Tower	Percent Increase in Feed Capacity	Percent Savings in Installation Cost
(a) Grids vs bubble caps, new towers for same throput			
Deethanizer	5'-6"x 80'		30
Stabilizer	7'-6"x110'		30
Prefractionator	7'-0"x100'		45
(b) Replacement grid trays in existing bubble tray tower vs cost of new bubble tray tower to handle increase in capacity			
Depropanizer	3'-6"x 80'	55	80
Deethanizer	4'-6"x 75'	65	80
Propylene Fractionator	4'-6"x150'	55	70
(c) Replacement grid trays in existing bubble tray tower, primarily for better tray life and maintenance			
Depropanizer	5'-0"x 65'	45	40
Alcohol Acid Stripper	3'-0"x 30'	40	45

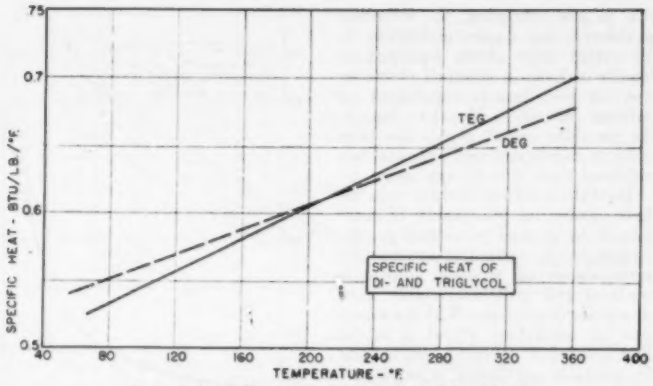

Figure 1. Specific heat of diethylene and triethylene glycol.

Dehydration of Natural Gas And Hydrocarbon Liquids

Part III. Liquid desiccant plants. Advantages and disadvantages of various desiccants are listed as are cost factors and operating variables.

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THE ABSORPTION type dehydration plants offer the advantage of continuous desiccant circulation, a high degree of flexibility, and relatively low cost. However, until recently, their use was limited by the availability of liquid desiccants that would give a high dew point depression and yet be relatively non-volatile and non-corrosive. The development of triethylene glycol dehydration plants in the past several years has spurred the use of absorption plants.

A good liquid desiccant should:

1) Maintain its drying ability over a wide range of concentrations.
2) Have a low vapor pressure at operating conditions.
3) Be non-corrosive in aqueous solutions.
4) Not have an excessive viscosity.
5) Be chemically and thermally stable, and non-hydrolyzing.
6) Be easy to regenerate without special equipment.
7) Be non-toxic.
8) Have a low heat of reaction and heat of solution.

A number of liquids have been used not all of which satisfy the above requisites. In some cases ready source of supply and price have been factors, such as the use of sulfuric acid for drying in chemical plants. The principal liquids now in use include: 1) triethylene glycol, 2) diethylene glycol, 3) glycol-amine-water mixtures, 4) calcium chloride, 5) glycerine, 6) lithium chloride and 7) sulfuric acid.

The latter three liquids have never been used to any extent in the petroleum industry. Sulfuric acid plants were at one time prevalent in the chemical industry while glycerine has been used to dry manufactured gas, but the number of such plants is declining. Lithium chloride has never been used to any large extent except for low temperature and air drying.

The chlorides and sulfuric acid offer advantage when drying low relative humidity gases since their water content at equilibrium is higher than the glycols. Above 90 percent relative humidity, however, this difference is slight.

A comparison of equilibrium moisture contents is largely academic inasmuch as equilibrium is never reached in the contactor. It is interesting to note however, that at equilibrium liquid desiccants will hold more water per pound than dry desiccants, but do not give as low effluent gas dew points.

Properties of Absorption Liquids

The general properties of the common liquids used in absorption are summarized in Table 1. Table 2 summarizes the advantages and disadvantages of these fluids.

Calcium Chloride brine is a cheap method of dehydration from the standpoint of initial equipment and solution costs.[1,2,11,22,24] In some locations a wet type scrubber is used and the gas simply bubbles through $CaCl_2$ brine in the base, the charge being dumped and replaced when saturated. Although this method has prevented freezing in gathering systems under some rather severe conditions it is crude and being replaced by more efficient well head triethylene glycol dehydrators. In addition, these small "chloride pots" are subject to corrosion. Due to their batch operation they have been used primarily on small gas gathering systems.

Continuous calcium chloride systems have been constructed for both the chemical and natural gas industries, particularly the former. Their use, however, has been limited by practical operational problems such as corrosion, liquid carryover, etc.

Lithium Chloride has been used chiefly in those industries where dehydration must be carried out at low temperatures.[17] Not only is it expensive but the equipment to handle it

TABLE 1
General Properties of Liquid Desiccants

Desiccant	Operating Range °F.	Conc. Range Percent	Corrosiveness	Stability	Principal Applications
Triethylene Glycol	40–100	95–100	Non-Corrosive	Stable	Drying Natural Gas and Air.
Diethylene Glycol	40–100	70– 95	Non-Corrosive	Stable	Drying Natural Gas and Air.
Glycerine	70–100	70– 80	Non-Corrosive	Oxidizes and Decomposes	Drying Manufactured Gas (Obsolete).
Calcium Chloride	90–120	38– 45	Corrosive	Stable	Dry City Gas and Some Natural Gas.
Sulfuric Acid	70–120	60– 75	Corrosive	Stable	Gas Drying in Chemical Plants.
Lithium Chloride	70–100	30– 45	Corrosive	Stable	Vacuum Drying at Low Temperature, drying Air.

NOTE: All of the liquid desiccants above, except sulfuric acid are non-toxic with respect to the effects of any vapor released during operation. However, the glycols should not be taken internally and the chlorides should be kept away from the eyes.

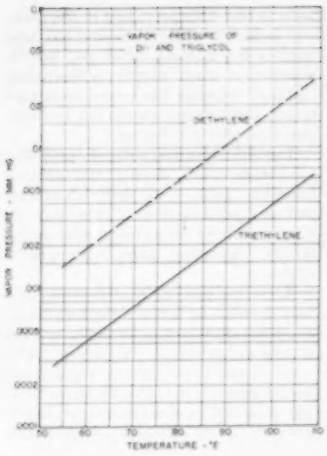

Figure 2. Vapor pressure of diethylene and triethylene glycol.

must be relatively complex, for dehydration plants. The heat exchange load is high since both solution and after coolers are needed. The dew point depression is good (40-67 F.) but economics limit its applications.[1]

Glycerine[3, 14] has been used in the manufactured gas industry but has never gained very wide popularity due to the low dew point depressions obtained (30-33 F.). It is viscous when highly concentrated and tends to foam in columns. Regeneration is also difficult for there is a tendency toward decomposition. All of these factors plus a high initial cost obviously limit the use of glycerine.

Sulfuric Acid has a high capacity for water when concentrated and is low in cost. However, the corrosion problem makes its use prohibitive in all except those plants equipped to handle it. Even in chemical plants its use has been largely supplanted by calcium chloride and other liquids. As yet little use of glycol has been used in chemical plants although calculations show it to be applicable.

Diethylene Glycol (DEG) was the first number of this family of compounds to be used in natural gas dehydration. As a fluid it satisfies the prerequisites of a good absorption medium and gives reasonably good dew point depressions. With the exception of triethylene glycol it is the best absorption liquid for general use. In available equipment, solution concentrations above 95 percent are not easily attained without exceeding the theoretical decomposition temperature and the use of relatively complex regeneration equipment.

Dew point depressions are usually limited to 50 F. in the larger plants while some give results as low as 30 F. Depressions have been somewhat limited because it was felt that reboiler temperatures could not exceed 328 F., the reported theoretical decomposition temperature of diethylene glycol.[12] Experience has shown that this temperature may be exceeded somewhat, in the absence of oxygen and hydrogen sulfide, without noticeable decomposition. Consequently some plants are now operating satisfactorily at 330-350 F. and most of the reports to date are favorable. At those temperatures higher concentrations of glycol are obtained which increases the dew point depression.

Before raising the reboiler temperature, it must be determined if the existing stripper reflux equipment and liquid cooling capacity are large enough to handle the increased heat load. This equipment, together with the reboiler size, prevents the higher temperatures from being used in many plants.

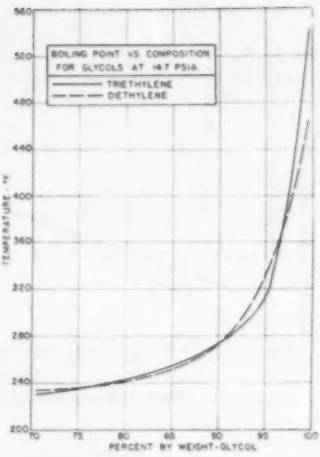

Figure 3. Boiling point—composition curves for diethylene and triethylene glycol — water solutions.

The use of temperatures above 325 F. with diethylene glycol is not recommended as a general practice but only as a matter of necessity to increase the dew point depression of existing plants. In the design of a new plant for higher depressions, where a liquid desiccant is planned, triethylene glycol is recommended.

Glycol-Amine mixtures should be mentioned although they are installed primarily for the dehydration of gases containing H_2S and CO_2. The exact mixture of monoethanolamine (MEA) diethylene glycol (DEG) and water used varies somewhat with the process requirements. One of the largest installations of this type however, uses a mixture with 10-30 percent MEA, 5-10 percent water and the remainder DEG. With this mixture the H_2S content may be lowered to less than 0.25 grains per 100 scf.

Regeneration is usually carried out at 300 F. in order to generate steam to break down the MEA sulfides and carbonates that are present. At these temperatures severe corrosion is often encountered which necessitates the use of special materials. Liquid carryover from the absorber is also common and introduces an after-scrubbing problem. Dew point depressions as high as 50 F. are reported in the literature from plants using this mixture.[3, 4, 8, 26] Amine itself is hydroscopic but part of this advantage is lost by the limited regeneration of the glycol, i.e., the absorb-

TABLE 2
Summary of Advantages and Disadvantages — Absorption Liquids

LIQUID	ADVANTAGES	DISADVANTAGES
Calcium Chloride	Cheap. Makeup small (0.1 – 0.4 pound per Mmcf.)	Emulsifies with oil. Corrodes electrolytically. Low dew point depression (20-35 F.) Hydrogen sulfide forms precipitates.
Lithium Chloride	High capacity for water. Low corrosion rate. Not hydrolyzed easily. Dew point depression 40-67 F.	Expensive. Impurities in commercial grades cause corrosion.
10-30 Percent MEA, 60-85 Percent DEG, 5-10 Percent Water.	Removes CO_2, H_2S and water simultaneously. Glycol reduces foaming tendencies of amine. Dehydrates and purifies gas in one operation.	Greater carry over than with triethylene glycol. Limited for practical purposes to sour gas dehydration. At high regeneration temperatures needed corrosion is a problem. Dew point depression is limited and less than with triethylene glycol.
Diethylene Glycol	Stable. Does not solidify in concentrated solution. Stable in presence of sulfur, oxygen and CO_2 at normal operating temperatures. Highly hygroscopic. Carry over is small.	Carry over greater than with triethylene glycol. Not over a 95 percent solution may be obtained easily. Dew point depression less than with triethylene glycol (30-60 F.). High initial cost.
Triethylene Glycol	Does not solidify in concentrated solution. Stable in presence of sulfur, oxygen and CO_2 at normal operating temperatures. Highly hygroscopic. Easily regenerated to 99 percent solution. Carry over small. High dew point depression (30-85 F.)	High initial cost. Exhibits some foaming tendency in presence of light hydrocarbon liquids. Defoaming agent must sometimes be added.

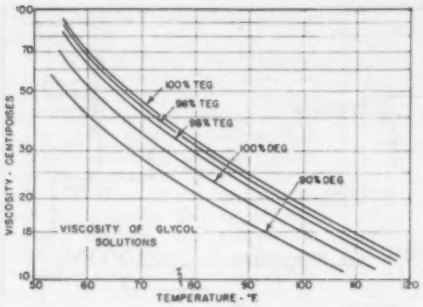

Figure 4 (at left). Viscosity of diethylene and triethylene glycol—water solutions.

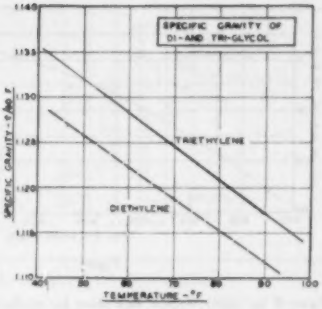

Figure 5 (at right). specific gravity of diethylene and triethylene glycol.

ing solution is not as lean as with glycol alone. At the average gas flowing temperature it is difficult, at best, to dehydrate to 7.0 lb. H_2O per Mmcf. For sour gas operations, where high dew point depressions are not necessary, this system has given some excellent results. Economics, however, limit its use to such systems.

Triethylene Glycol (TEG) is the newest and best liquid for natural gas drying since it gives a high dew point depression, is easily regenerated, and exhibits small vaporization losses. Its properties are summarized in Tables 1 and 3.

A large number of the type of plants shown in Figure 8 are now in use with capacities ranging from 2 to 200 million standard cubic feet of gas per day. The success of these plants has been due to both the inherent advantages of triethylene glycol (TEG) and design features which insure flexibility and dependable operation. Liquid carryover is less than 0.1 gallon per Mmcf and usually approximates 0.025 gallons per Mmcf.

Triethylene glycol offers the advantage over diethylene glycol of a higher boiling point (549 F.), which makes it easier to concentrate. Consequently 99 percent solutions may be obtained in the stripper at atmospheric pressure.

The vapor pressure of triethylene glycol is only about 20 percent that of DEG at 80 F., which results in lower vaporization losses from the absorber. Liquid losses are thus reduced when proper precautions are taken to eliminate entrainment.

Early laboratory data[19] indicated that the drying efficiency of TEG systems declined above 1000 psig. Subsequent examination of these data, however, shows that condensation occurred in the dynamic equilibrium system at the higher pressures, giving erroneous results. Triethylene glycol plants with a working pressure of 2000 psig are now operating successfully in the field.

In view of the present day importance of the glycols, as compared to other absorption liquids, the remainder of the discussion will concern their properties and equipment considerations. Triethylene glycol systems are stressed since diethylene systems have been widely discussed in the literature.

Properties of Di- and Triethylene Glycol

Several properties of the glycols are necessary in order to make the computations for the component parts of the dehydration plant. The best values now available are summarized in the tables and Figures 1-7. These values may be used in making heat balances and the design of the heat exchangers, pumps, absorbers, and stripping column.

The data shown point out the relative advantages and disadvantages of each of the glycols. Actually their properties are quite similar except for vapor pressure, but this is an important consideration.

Specific Heat. The slope of the specific heat curve for triethylene glycol is greater than that for DEG, as shown in Figure 1. Since the curves cross there is little net difference in the average specific heat of the two liquids. However, the reboiler on a TEG system operates at higher temperature which increases the total sensible heat load, although this difference is partially nullified by the additional heat transferred in the glycol-glycol exchanger. Actually the largest reboiler heat load is vaporizing the water absorbed and that from the reflux. Inasmuch as more water is absorbed the TEG reboiler load is proportionately higher.

Vapor Pressure. Figure 2 shows the vapor pressure of diethylene and triethylene glycol at various temperatures. The relatively low vapor pressure of TEG shown accounts for the large difference in the design of the two systems. The bubble point at atmospheric pressure is correspondingly higher which increases the ease of stripping out the water. By the same token vapor losses are reduced in the absorber if proper steps are taken to prevent mechanical entrainment.

TABLE 3
Properties of Di- and Triethylene Glycol

	Diethylene Glycol	Triethylene Glycol
Synonym	Diglycol	Triglycol
Molecular Weight	106.12	150.17
Formula	$C_4H_{10}O_3$	$C_6H_{14}O_4$
Specific Gravity, 20/20 C.	1.1184	1.1254
Boiling Point—°F. (14.7 psia)	473	549
Freezing Point—°F.	18	19
Solubility in Water, 68 F.	Miscible in all proportions	Miscible in all proportions
Viscosity, Absolute, 68 F.	35.7 centipoises	47.8 centipoises
Specific Heat, 68 F.	0.545 Btu. per pound per °F.	0.525 Btu. per pound per °F.
Heat of Vaporization, 1 atmos.	160 Btu. per pound	179 Btu. per pound.
Reported Theoretical Decomposition Temperature—°F. (12)	338	404

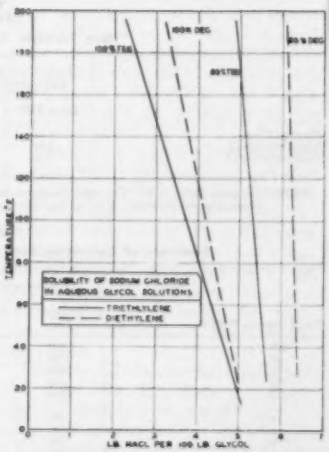

Figure 6. Solubility of sodium chloride in diethylene and triethylene glycol.

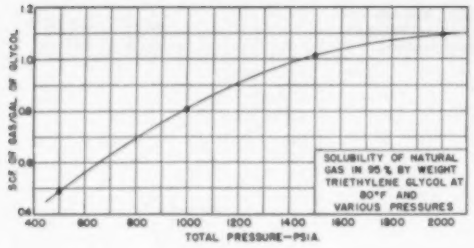

Figure 7.

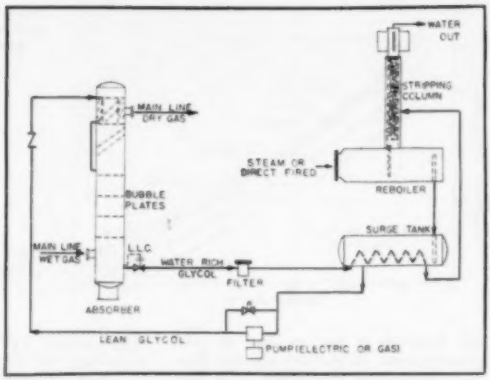

Figure 8 (at right). Typical flow sheet for triethylene glycol dehydration plant.

In cases where the reboiler temperature is limited by the decomposition temperature of the glycols, it is possible to obtain leaner solutions of TEG than of DEG, as illustrated by the bubble point curve shown in Figure 3. While extensive data show that these temperatures do not apply to natural gas systems in the absence of oxygen, operating above them certainly cannot be recommended as a general practice. Actually, the concentrations shown are increased by effective stripping.

Viscosity. As shown in Figure 4, the viscosity of TEG is higher than that of DEG. This has two chief effects on design; it increases the pressure drop in the liquid piping and decreases the plate efficiency slightly. Little difference in pressure drop is noted in operation however, since the flow rate is small. The slightly lower plate efficiency is offset by the leaner TEG solution with the net result that a bubble plate using TEG will pick up more net water than one with DEG, under comparable conditions. Exact over-all plate efficiency data are limited by the lack of concise equilibrium information but values of the order of 70 percent are indicated, which is evidence of the very hydroscopic nature of the glycols.

Pressure has a marked effect on the atmospheric viscosities shown in Figure 4.[6] For example, at 1000 psig the viscosity of diethylene glycol is about 3 to 4 times that shown at atmospheric pressure. This means that with a given inlet solution concentration, the circulation rate must be increased in the absorber to compensate for the loss in plate efficiency with the higher viscosity. Consequently when going to higher pressures the glycol circulation rate is not a direct function of the water content of the gas.

Specific Gravity. As shown in Figure 5 the specific gravity of TEG is higher than DEG as would be expected from the molecular weight. The values shown are of interest primarily for conversion factors inasmuch as the slight difference in density has little effect on the system design. Actually the higher density increases the pressure drop due to friction but the lines are short and this loss is negligible when compared to that taken across the regulators.

Solubility of Sodium Chloride in the Glycols. In normal operation the solubility of Sodium Chloride is not a factor since any absorber should be protected by an inlet scrubber. However, for those cases where such a scrubber has not been installed, or malfunctions, solubility data is of interest.

The data in Figure 6 show that salt is more soluble in diethylene than in triethylene glycol. This is also primarily of academic interest since both must be regenerated before the solution becomes saturated. This salt contamination is one of the reasons why glycol plants should always be protected with an inlet scrubber because the chance of the fire tubes becoming fouled, with possible burnout, is involved.

Once salt contamination has been obtained to any degree one solution is to remove the glycol charge and vacuum distill it. The liquid goes overhead leaving a residue to be discarded. Although this sounds complex, in reality "home made" columns have been built for this purpose using steam for obtaining a vacuum. At best though the operation is time consuming. Since salt water cannot always be anticipated it should be emphasized again that all dehydration equipment, regardless of

TABLE 4
Heat of Solution of Water in Infinite Amounts of Glycols

Solute	Solvent	Temperature F.	Heat of Solution Btu./Lb. H_2O
Water	Ethylene Glycol	86	48
Water	Diethylene Glycol	77	58
Water	Triethylene Glycol	86	91

TABLE 5
Heat Transfer Factors for Glycols

	HEATING OR COOLING REYNOLDS NUMBER		Vapor Heating or Cooling	Condensing Vapors	Boiling Liquids
	Below 2100	Above 2100			
Ethylene Glycol	0.49	0.12	0.60	0.18	0.30
Diethylene Glycol	0.50	0.11	0.60	0.17	0.30
Triethylene Glycol	0.49	0.09	0.60	0.15	0.30

NOTE: The water factor = 1.0. The above factors are multipliers which are used to correct for those heat transfer coefficients obtained for water. Multiply the coefficient obtained for water by the above figures.

TABLE 6
Summary of Operating Data Triethylene Glycol Dehydrators

Rated Capacity MMCF	GAS CONDITIONS		Glycol Circulation Rate—Gal./Hr.	Outlet Dewpoint °F.	Dewpoint Depression °F.
	Pressure, Psig.	Temperature, °F.			
200	700	68	1200	−7	75
30	720	78	151	5	73
20	1000	84	104	0	84
14	680	82	65	7	75
20	1000	37	110	11	76
9	740	83	48	5	78
4	690	76	13	25	51
4	540	74	11	8	66
4	635	78	15	19	59
4	525	72	8	8	64
4	1430	80	14	16	64

type, should be protected by an inlet scrubber.

Solubility of Natural Gas in Glycol. Figure 7 represents data taken on natural gas solubilities.[19] These data emphasize the low solubility of natural gas in glycol. Because of this no flash tank is necessary when dumping glycol from the absorber to the atmospheric still column since the vaporization load is negligible. The natural gas evolving from the still column, together with any vaporized condensate, constitutes some hazard and should be piped away from any direct fired reboiler. With most of the large units, the reboiler is placed 100-150 feet away from the absorber and the main gas line.

Flow Diagrams

Figure 8 is a typical flow sheet of the most common triethylene glycol plant, while Figure 9 is representative of diethylene glycol plants.

In the triethylene glycol plant the gas enters near the bottom of the absorber and contacts the solution on a series of bubble trays, after which it passes through a double spray condenser. The effluent gas then flows over helical coils to cool the incoming glycol in those cases where additional cooling is needed. At low pressure, or for large glycol circulation rates, external heat exchange is sometimes necessary.

The incoming glycol enters on the top tray and flows by gravity across the various trays. After final contact it enters the liquid sump in the bottom, the level of which is controlled by a float controller on all except the small units. The glycol after being dumped from the absorber, passes through a filter for sediment removal and flows through a heat exchanger which is normally incorporated in the glycol surge tank on well head units. There the water rich glycol is preheated by the lean glycol which in turn is partially cooled before entering the pump.

The water rich glycol then enters the still column, flows downward into the bottom of the reboiler, and passes upward past the fire tubes by convection. The reconcentrated glycol then flows to the surge tank through an overflow pipe. This overflow pipe not only keeps the fire tubes covered but also prevents the liquid from flooding into the still column. This overflow system has been found to be simpler and more reliable than the use of a level controller at this point.

The reflux for the atmospheric still column is supplied by air fin coolers on the top. Field data have shown that the amount of reflux needed is small due to the widely divergent boiling points of the liquids being separated.

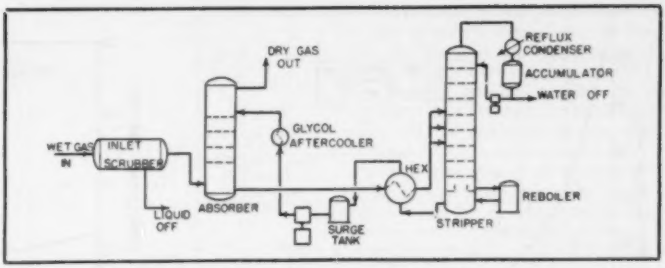

Figure 9. Flow sheet for a diethylene glycol dehydration plant.

It has been found for example that as long as the packing above the inlet is wet, glycol losses from the still column are negligible. The fins are therefore sized to give that minimum amount of liquid needed at the maximum air temperatures expected.

The flow sheet in Figure 9, for diethylene glycol, is very much the same except that the regeneration equipment is more complex. Additional contact is needed in the stripper along with regular reflux equipment due to the narrower boiling point range. This additional equipment, together with an increased maintenance cost, are the principal reasons for the higher dehydration cost with this system.

Operation and Design Factors

Glycol dehydration is a simple application of absorption and fractionation but close attention to design details is essential because of the varying loads encountered and the fact that many units must operate with little or no skilled attention.

Absorber Design. The glycol absorber operates with a much lower liquid load than most such equipment so that the trays must be designed with that thought in mind. A smaller gradient is necessary across the bubble plate in question as a result of the low liquid pressure drop. Consequently it is easier

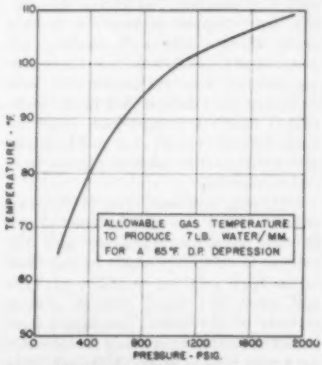

Figure 10. Allowable inlet gas temperature to give seven pounds of water per million with a 65 F. dewpoint depression.

to maintain a stable plate from the standpoint of all caps working. The cap spacing is governed by the velocity of the gas emerging from the slots so that proper turbulence is maintained. Standard design methods are adequate in determining this spacing.

The system shown in Figure 8 uses a double spray condenser, the primary unit being built so that the gas must change direction a number of times. The liquid is then trapped in pockets by centrifugal action. The second section is composed of a sloping packed section. Field tests have shown that this arrangement substantially reduces liquid carryover and is one secret of the low glycol loss. Some absorbers have been built with inlet spray condensers but the use of an inlet scrubber eliminates this need.

Glycol exhibits some foaming tendency in the presence of light hydrocarbons. Therefore this limits the allowable vapor velocity through the slots in the caps. In normal operation with good inlet scrubbing, this is no problem but if it occurs an anti-foam lubricant may be used to break the foam.

Data from the University of Oklahoma[18] indicate that the triethylene glycol equilibrium vaporization loss is about 0.012 gallons per Mmcf at average absorber operating conditions. Extensive field data show a total glycol loss of about 0.025 gallons per Mmcf, which indicates the efficiency of the dual condenser.

Extensive use of the above type triethylene glycol plants has shown that the absorber performance has exceeded original expectations. Dew point depressions have usually been 70 F. and greater in the large plants and it has been possible to guarantee 65 F. depression in many instances. This is a substantial increase over the dew point depressions obtained in past absorption plants.

The plate efficiencies have remained high over wide variations in column loading which is evidence of plate stability and proper bubble cap design.

The circulation rate averages about three gallons of TEG per pound of water absorbed. With four bubble trays

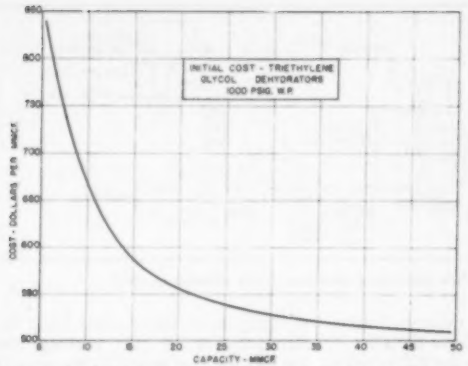

Figure 11. Typical initial cost curve for triethylene glycol dehydration plants.

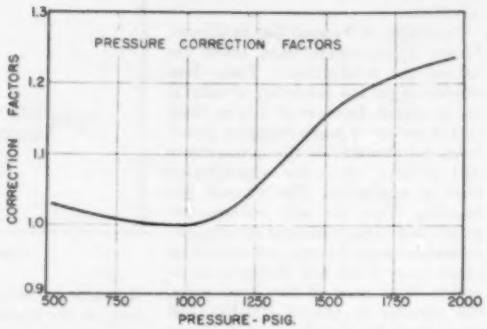

Figure 12. Cost correction factors for variation in operating pressures (See Figure 11).

the maximum effective circulation rate is about seven gallons of TEG per pound of water. Therefore if more contact is needed additional trays are added.

With diethylene glycol the circulation rate is usually adjusted so that the water rich solution contains about 91 to 93 percent DEG by weight.

Filter. A filter is an essential item inasmuch as it prevents debris and "muck" from entering the reboiler. If processing sour gas some iron sulfide is formed which is a source of erosion-corrosion. By keeping the glycol clean, tube burnout in the reboiler has become a rare occasion.

Glycol will absorb hydrogen sulfide to some extent so when dehydrating very sour gas some inhibitor is often necessary to prevent corrosion in the reboiler. Several commercially available materials have been used with success. Although many units are dehydrating slightly sour gas with no evident corrosion the addition of an inhibitor in such cases seems good preventive maintenance. Hydrogen sulfide turns glycol black due to iron sulfide but this has no apparent effort on the hygroscopicity of the glycol.

Heat Exchange. The first consideration is to cool the hot glycol from the reboiler down to approximately absorber temperature. This is normally accomplished by using the cool water-rich glycol from the absorber in order to conserve heat. With the large temperature differential available and the approximately equal volumes of fluid, this is efficient. On large plants, or those where a high circulation rate is needed, it is economical to design the exchanger to give a low degree of approach. On well head units, with lower circulation rates, compactness and economics dictate the use of both this cool glycol and the sales gas stream. In this case coils may be placed in both the surge-storage tank and in the top of the absorber.

When using the two streams for cooling from 50-75 percent of the heat is transferred in the liquid-liquid exchanger and the remainder in the absorber. The proportion is governed by the amount of coil that may be placed in the surge tank and the allowable temperature rise of the gas. In most units this rise does not exceed 5 F.

When the relative glycol to gas flow rate is low enough to permit the use of the absorber cooling coils an approach in excess of 25 F. seems satisfactory. Field tests indicate that this difference has no effect on the degree of dehydration.

The use of the absorber exchanger has the additional advantage of serving as an after-cooler on the fluid leaving the pump. In the average installation, however, the rise in temperature on pumping is negligible in comparison to the overall heat transfer picture.

The use of a larger glycol-glycol exchanger for all of the cooling has the advantage of giving more preheat to the water rich solution going to the stripping column. The glycol then enters the stripper nearer its bubble point whereas with split cooling this temperature is 300 F. or less. The question of how to handle the heat exchange must be decided in the individual case. A comparison must be made between initial cost and fuel cost along with factors such as compactness and portability.

Stripping Column. The stripping column used on triethylene glycol systems contains packing and the column is relatively small in size. Due to the high relative volatility of TEG and water the vapor consists almost entirely of the latter. The liquid load is therefore the controlling factor since the vapor load is small. Although little glycol reaches the rectification section the degree of separation accomplished pays dividends. The glycol loss from the stripper of the plants shown is negligible.

With atmospheric cooling the rate of reflux necessarily varies with air temperature. Field tests show that the reflux ratio, based on the water in the entering feed, varies from 10 to 100 percent. The higher rates occur only when the unit is operating at well below rated capacity for at or near rated capacity 25 percent is about average. The fluctuation of reflux is one disadvantage of internal reflux, although in this case it has no noticeable effect on column performance, as a result of the easy separation. High reflux ratios increase the reboiler heat load but this is more than compensated for by the increased ease of operation, with a resultant decrease in cost and maintenance.

Diethylene glycol has a higher vapor pressure which directly affects the amount of rectification needed. Consequently a higher degree of control on the reflux is needed together with more vapor-liquid contact. Therefore such systems normally employ conventional reflux equipment and longer towers. The system shown in Figure 11, with trays is typical of many installations. The reboiler considerations are substantially the same as those with triethylene glycol.

Reboiler. The reboiler must be designed to handle any sensible heat load on the feed and the heat of vaporization for both the absorbed water and reflux. The latter load may be estimated from the expected dew point depression and the reflux load at the lowest temperatures anticipated. At 375 F. the heat loss from the reboiler should not exceed 5-10 percent.

The over-all thermal efficiency of the direct fired reboiler compares favorably with that when steam coils are used. For example, the overall efficiency of the direct fired reboiler

for the system shown is about 70 percent.

The level may be maintained either by a controller or an overflow pipe. If the former is used the float is normally located in the reboiler and the valve on the absorber. This system has two inherent disadvantages; there is a time lag between the time when the pilot adjusts the dump valve and the effect shows up in the reboiler, and failure of the pilot or valve might result in a low liquid level resulting in fire tube burn out. The overflow system on the other hand minimizes these disadvantages. The level in either case must be carried low enough to furnish sufficient vapor withdrawal area.

A direct fired reboiler characteristically shows a temperature variation of a 5-10 F. when firing intermittently. Although this would not be tolerable with some systems it has no noticeable effect in this case.

Two thermostats are advisable, one for control and one for a high temperature shutoff in the event the other fails to operate. These thermostats are normally set at 375 F. and 400 F. respectively.

Pumps. The absence of dependable electrical power on most leases dictates the use of gas driven pumps. Even though the value of the gas so used is high the cost is still low. Single stage piston type steam pumps are usually adapted for this service since they are dependable and require little maintenance.

The exhaust gas from the pump may be used to fire the reboiler. It should be borne in mind however, that this raises the exhaust pressure on the pump thus increasing the pump consumption in standard cubic feet. Each situation must consequently be examined to see if this arrangement reduces the over-all gas consumption.

On large installations gas engine driven pumps are economical since it is easier to justify the higher initial cost. However, such plants usually have a dependable supply of electricity available. On transmission lines where continuous service is essential it is good practice to install electric pumps with gas standby facilities. This system may be made automatic by using a low flow controller on the glycol discharge line so that if the flow stops, the instrument will open a valve on the line supplying gas to the power cylinder. This system is virtually infallible since the gas pump has power as long as the main gas line is under pressure.

Economic and Process Factors

Temperature. The gas temperature is the key factor affecting the potential use of a glycol dehydrator. As the gas temperature rises above 80 F. the following factors must be taken into account:

1) The degree of contact to offset any lowering of the absorption efficiency.
2) The degree of contact needed to produce a gas with the specified dryness.
3) A glycol circulation rate sufficient to handle the increased water load without excessive glycol dilution. Larger reboilers, pumps and heat exchangers are therefore required.

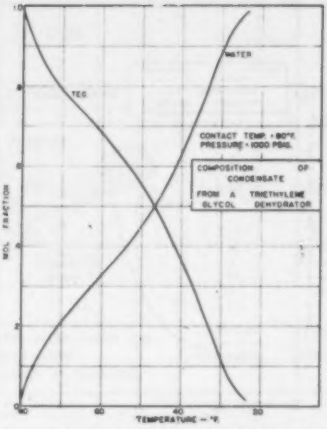

Figure 13. Typical condensate composition when cooling dehydrated gas from a triethylene glycol plant.

The highest guaranteed dew point of commercial units is 65 F. although greater dehydration is characteristically obtained with some of the larger triethylene glycol plants. If the specifications call for a water content not to exceed seven lb. per million standard cubic feet, the allowable contact temperature is a function of the system pressure. Figure 10 gives the allowable temperatures for producing seven pound gas with a 65 F. depression.

If the flowing temperature is too high for the effective use of glycol some means of cooling warrants investigation. Glycol dehydration economics are relative since they are usually compared with those of dry desiccant. Inasmuch as the initial cost of the former is less than half that of dry desiccant the dollar difference on larger plants is substantial and an additional expenditure for cooling the gas may often be justified. The cooling may be accomplished in any one of three ways:

1) Expansion cooling of the gas above the hydrate point if pressure drop is available.
2) Use of water in conjunction with a cooling tower.
3) Mechanical refrigeration.

Method one is not meant to apply for these cases where expansion refrigeration dehydration plants are feasible. Rather it is applicable where a several hundred pound drop is available for the cooling needed. As a secondary consideration additional liquid will be recovered in the inlet scrubber.

Method three is a relatively new application of refrigeration. The refrigeration may be of the compression type using either electric or gas engine driven compressors, or the absorption type. The latter is ideal for this service, requiring no compression facilities (See Part V of this series).

Pressure. Effective dehydration is being obtained with units of 2000 psig working pressure. Contrary to early information pressure has little effect on the dew point depression that may be obtained, at least up to this pressure. All available data indicate that pressure above 2000 psig may also be used. As previously discussed, however, a slightly higher glycol circulation rate is necessary.

Initial Plant Cost. Figure 11 may be used to estimate the initial equipment cost for a 1000 psig working pressure triethylene glycol plant. At other working pressure these cost figures should be multiplied by the correction factors in Figure 12. With plants larger than 50 Mmcf capacity a price of $500. per million is satisfactory for estimation purposes.

The curves shown are sufficiently accurate for estimation purposes, although costs vary somewhat with the manufacturer and construction details. The pressure correction factors are average figures since the effect of pressure on cost varies with the size of the unit.

The curve in Figure 12 passes through a minimum because of the nature of the equipment. At low pressure the reboiler, pump and heat exchanger are larger because of the high gas water content. As the pressure increases the cost of these items decreases and eventually levels off.

Although the diameter of the absorber, for a given gas flow, decreases with pressure increase, the wall thickness is greater. The two cost curves for the absorber and other components cross which produces the minimum in the overall cost figure.

Even with this fluctuation it is significant that the equipment cost for TEG is less than half that of dry desiccant.[9] The cost figures shown do not apply to diethylene glycol plants, which are higher.

Operating Costs. The cost of operating a plant necessarily varies with the accounting system used for proportioning costs. Since most glycol plants are automatic the portion of the op-

erator's time charged varies.

Based on expected gas consumption, average glycol loss and estimated maintenance, the cost should average about $0.40 per million standard cubic feet with triethylene glycol. Most field reports to date show a variation of $0.20-$0.60 with one source of published information showing the minimum cost.[16]

Measurement of Water Content

Although measurement of water content is a subject within itself it is briefly reviewed here since it is an integral part of the dehydration picture, and one subject which is very controversial. The most widely accepted means has been the Bureau of Mines dew point tester but unfortunately this instrument is subject to a human error which may be large. Liquids in the gas other than water often interfere with the spot on the mirror which makes it difficult even for the trained operator to obtain reproducible data.

The use of any dew point tester also requires a water content chart. A number of these have been developed but they often are in disagreement. There is some evidence to support the premise that at least part of this stems from differences in gas composition. However, the chart of McCarthy, Boyd and Reid (See Part I), which is a correlation of various data has given excellent results in many instances.

At least part of the controversy over "what is a dew point" stems from the fact that the term is a misnomer when applied to most gas systems. The true dew point is that temperature at which the first droplet of liquid of any kind condenses and bears little relation to the temperature at which water will condense when present with some other miscible component. When the gas contains nothing but hydrocarbons and water, two virtually immiscible materials, adequate results are obtained by reading both a hydrocarbon and water dew point. However, when a water soluble material such as glycol is present the situation is complicated somewhat.

Riesenfeld and Frazier[20] have published data on diethylene glycol systems which show that the actual water content is about 5 F. lower than that equivalent to the temperature at which a stable spot appears on the tester mirror. Although this makes the use of a tester questionable for positive work on such systems the error is in the right direction from the operator's standpoint since a margin of safety is provided.

On the basis of this work investigations were made of the instrument's accuracy when used on effluent gases from triethylene glycol dehydrators.

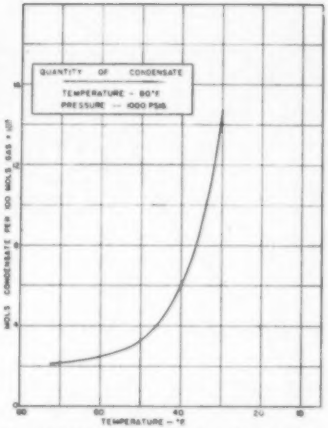

Figure 14. Relative quantity of condensate when cooling dehydrated gas from a triethylene glycol plant.

The results of these independent investigations have been recently published.[10, 18]

Figure 13 shows that the composition of the condensate first obtained on cooling is almost entirely glycol, due to the lean solution contained on the top tray. As the temperature is lowered further the percentage of water increases until the liquid is virtually all water, since the water to glycol ratio in the effluent gas is about 500:1. It is significant that the temperature at which the solution becomes substantially water coincides almost exactly with the "dew point."

This can only be true because of the very high water-glycol ratio in the vapor. Although water is condensed above the "dew point" the quantity involved is very small, and inhibited with glycol, so that from an over-all standpoint there is little effective change in the system.

On the basis of this information the tester is really measuring a point at which the quantity of glycol becomes so small that it has little inhibiting action. Regardless of what this point is called; dewpoint, equivalent water dew point, etc., it roughly coincides with the actual water content of the gas.

These results confirm therefore that the results obtained are about the same as if water had been the only miscible liquifiable constituent in the vapor. Furthermore the amount of water condensing with the glycol constitutes no hydrate hazard until the "dew point" is reached because of the inhibiting action of the latter. The line is still "dry" because the total amount of condensate is relatively small, which is borne out by field checks.

Figure 14 illustrates the effect of temperature on the relative quantity of condensate. Liquid is present at the contact temperature since the total glycol loss exceeds the equilibrium quantity slightly. The curve further emphasizes the large ratio of water to glycol.

These investigations further checked the accuracy of a properly used dew point tester, by means of material balances. The results indicated an accuracy of ± 2.0 F. with triethylene glycol systems. The closer check than with DEG may be attributed to the leaner solution, lower carryover and low vapor pressure of the solution contacted by the gas.

Automatic dew point testers to eliminate the human error have been developed and look promising. At present the initial cost makes their use prohibitive in most cases.

Gravimetric and analytical methods have been developed but their effective use in the field is doubtful. Gravimetric methods require very accurate weighing while the analytical ones need standard chemical solutions which must be carefully handled. In the laboratory, however, these methods are excellent. A system of collecting the water coming off the dehydration plant has also been used for routine control work with some success.

All of the above devices have been used with success so that to a large degree the choice of a dew point measuring device is a matter of personal preference.

ACKNOWLEDGEMENT

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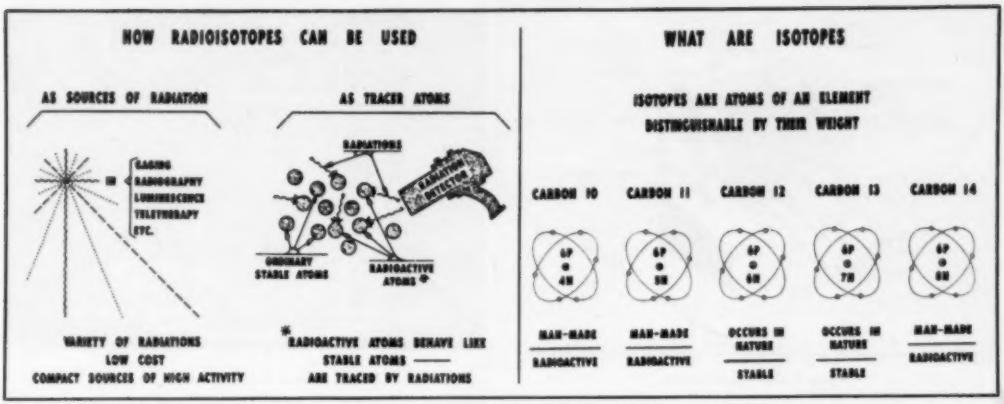

Figure 1. Basic uses of isotopes.

Figure 2. Isotopes of carbon.

Check these Uses for RADIOISOTOPES

- Mixing Studies
- Concentration Measurement
- Flow Studies

Jerome Kohl
Tracerlab, Inc., Berkeley, Calif.

THE RECENT availability of inexpensive radioisotopes from the reactors of United States, Canada, Great Britain, and France has resulted in a number of chemical engineering applications which are discussed in this paper.

Radioisotopes have been used for engineering studies since 1913. In that year, Hevesy and Paneth[1] determined the amount of water flowing in a river and measured the rate of self-diffusion in lead. Their work was carried out using naturally occurring radioisotopes. In the period 1913 to 1946 cyclotrons provided a few radioisotopes for wear studies. In August, 1946 the U. S. Atomic Energy Commission started shipping radioisotopes. In the period August, 1946 to the present, the U. S. AEC has made over 27,000 shipments of radioisotopes.[2]

Radioisotopes used in the United States are produced in the 2,000-KW Oak Ridge Reactor pictured in Figure 3. This reactor is 47 feet long, 35 feet high, 38 feet wide and has concrete walls 7 feet thick. The radioisotopes are produced both by fission of the uranium and plutonium and by activation due to the aborption of reactor neutrons. Fission produces radioactive elements ranging from element 30 to element 64, including zirconium, columbium, cerium, barium, iodine, strontium, ruthenium and cesium. Any element with a satisfactory neutron activation cross-section can be placed in the reactor and converted to a radioisotope. This technique is used to activate materials such as gears, piston rings, oil soluble antimony compounds. Radioisotopes from the U. S. Atomic Energy Commission range in price from 50 cents to $5000 a millicurie. Many are available at under $1 per millicurie and as will be discussed later, one millicurie is frequently sufficient for an experiment. U. S. AEC radioisotopes are only available for research work to users possessing health survey instruments and with some training in handling the activity. This training can be obtained in a four weeks' course at the Oak Ridge Institute for Nuclear Studies or in an intensive two weeks' course at one of the commercial radiochemical laboratories.

Radioisotopes are normally measured for health physics purposes by an ionization chamber or their radiations are counted for detection purposes with the sensitive Geiger-Mueller Counter. Other less common instruments include: scintillation counters, electrometers, proportional counters.

Radioisotopes are useful as sources of radiation and as tracers. Their tracer use arises because they exhibit

DEFINITIONS

Nuclear Reactor: An assembly of fissionable material capable of supporting a controlled nuclear chain reaction involving the production of heat, gamma radiation neutrons and fission products along with the consumption of fissionable material.

Radioisotope: Atomic species of the same atomic number that belong to the same element but have different mass numbers and that emit radiations in disintegrating to stable atoms. Figure 2 presents the five isotopes of carbon, including the long-lived carbon-14 used in many applications.

Millicurie: A millicurie was originally defined in terms of radium it is now commonly used as a unit of radioactivity corresponding to 2.2×10^9 dpm.

Alpha Particles: The nuclei of helium atoms (mass 4 — basis O = 16 — charge + 2) are emitted by many naturally occurring radioisotopes. Alpha particles are readily stopped and find use in industry in pressure gauges and static elimination.

Beta Particles: Electrons ejected from a nucleus (mass 1/1840, charge —1). Beta particles are readily detected by the G-M counters and are useful in measuring density concentration and paper thickness.

Gamma Rays: Electro-magnetic radiations produced in nuclear disintegration (zero charge and mass). The penetrating property of gamma rays makes them useful in radiography, level measurement, and in detecting buried objects or liquids in steel vessels or pipes.

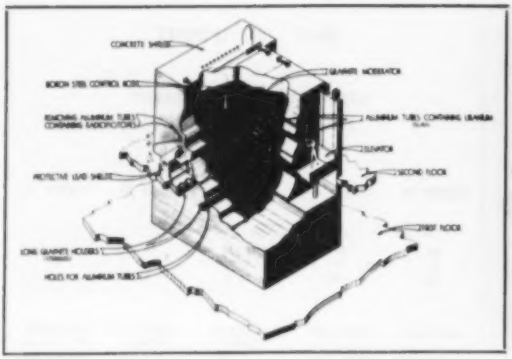

Figure 3. Oak Ridge reactor.

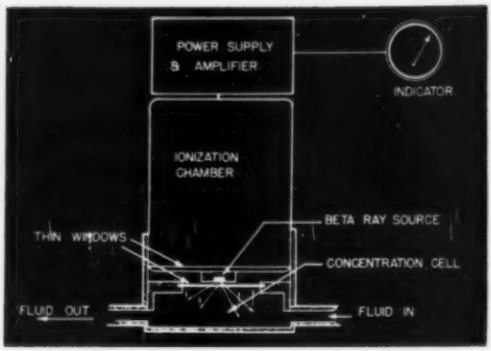

Figure 4. Backscattering concentration gauge.

substantially the same chemical behavior as stable isotopes while emitting radiation which permits determining their identity and location. Figure 1 illustrates these two basic uses of radioisotopes. The applications that follow cover both of these properties.

• *Mixing Studies.* It is possible to use radioisotopes to determine the uniformity of mixing of liquids or dry solids.[3, 4] It is therefore possible to use oil or gasoline soluble tagged compounds to determine the quality of mixing in gasoline blending tanks. Using 175 millicuries of phosphorus-32 as an oil soluble phosphate compound it is possible to determine the quality of mixing in a 55,000-barrel tank. (350 millicuries of radioactive phosphorus-32 can be purchased from the U. S. Atomic Energy Commission for $33 plus $10 handling charge.)

• *Concentration measurement.* Since beta backscattering is sensitive to the atomic number of the backscattering material, high atomic number ions in a low atomic number medium can be detected by a backscattering technique. For example, it is possible to detect lead, silver, copper, nickel, or vanadium in water or in a solid, such as paraffin. For the measuring device, a modified beta backscattering gauge is satisfactory.[5] A strontium-90 source can be used for the beta rays. (Sr-90, 25 years half-life, $1/mc) Figure 4 illustrates this instrument. Since gamma ray scattering is also a function of the atomic number of the scattering medium, gamma rays may be used for obtaining compositions.

Another technique for measuring concentrations involves counting the disintegrations per minute from radioactive atoms present in the compound to be detected, using a G-M tube. As an example of this technique Maloney at the University of Kansas has been using carbon-14 (C-14, 5100 years half-life, $36/mc) tagged methanol and ethanol in their studies of multicomponent distillation.[6] They have been feeding the tagged compound into their two-phase distillation system and determining the relative concentration of the tagged methanol or ethanol by simply counting samples of the liquids on various trays of the tower. Counting as used by radiochemists refers to a determination of the number of disintegrations per unit of time of a given radioactive material. In the case of the work at the University of Kansas, the counting is done using an end-window Geiger-Mueller tube. The weak beta radiation (.15 Mev) emitted by carbon-14 requires the use of a tube with an end window approximately two milligrams per square centimeter or of a so-called windowless counter. The work at the University of Kansas has really just started and the University predicts that they will be able to carry out distillation studies much more rapidly using C-14 than by using any other analytical techniques.

• *Flow Studies.* In some interesting studies of flow rate and flow patterns, Archibald[7] at Harvard has been using iodine-131 as a soluble iodide. He precipitates the I-131 from his water samples as silver iodide and counts the solid with an end-window G-M tube. In a study of retention time in a 60-foot x 35-foot x 8.75-foot deep primary sedimentation tank 5.4 millicuries of iodine were used. (I-131, 8.0 day half-life, 75 cents/mc). In another test 5 milliliters (20 millicuries) of I-131 solution permitted determining flow patterns in a 4.9 acre pond. A pond test of this type using salt as a tracer would require 1000 pounds of salt. For oil refineries and chemical plants this technique should prove of value in studying flow patterns in settling tanks and separators and investigating the path of pollutants in rivers, harbors and lakes.

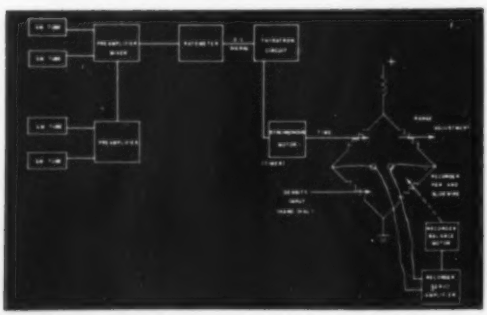

Figure 5. Block diagram of radioactive flow rate meter.

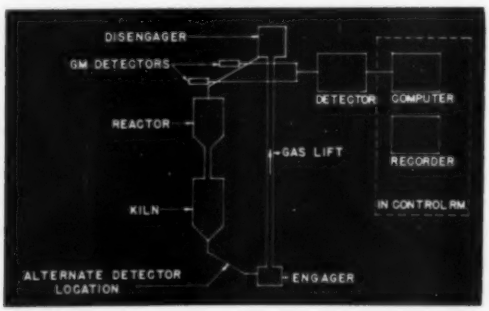

Figure 6. Measuring catalyst circulation in a Houdriflow catalytic cracker.

Figure 7. One millicurie of Sb-124 is injected in a product pipeline at Shell's Wilmington refinery.

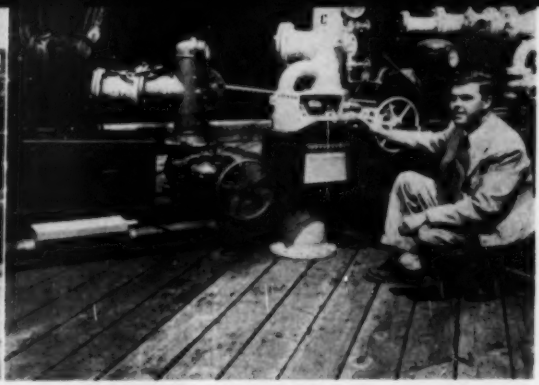

Figure 8. Twenty miles away (Los Angeles distribution center) mounted Geiger tubes record the radioactivity in the line, as initial product is displaced.

In a contained system flow study, the engineers of California Research Corporation used approximately 3 millicuries of an oil soluble antimony compound. An oil soluble compound, triphenyl stibene, can be prepared and irradiated, producing 20 millicuries of antimony-124 for a $50 irradiation. In the California Research study the antimony solution was injected into the reflux line of a large vacuum tower. The flow paths in the tower were subsequently studied by the use of a portable G-M tube survey meter. In this particular tower a number of downcomers were used between trays. Presence or absence of the antimony in each downcomer was detected by the effect of the gamma rays from the antimony on the G-M tube of the survey meter.

In another interesting application carried out by Dr. Donald Hull of California Research Corporation, radioactive catalyst beads were used to determine flow patterns and the catalyst circulation rate in a Houdriflow catalytic cracker.[8] For this work catalyst beads are tagged with 1 millicurie of zirconium-95 and the radioactive beads are placed in the system. The Zr-95 is a gamma-emitting radioisotope with a 65-day half-life and is worth $2 per millicurie. Two sets of Geiger tubes are placed 25 to 50 feet apart along a catalyst stand pipe. The two sets of Geiger tubes determine the time required for a radioactive pellet to pass between them. This time is fed into a computer into which is also fed the density of the catalyst and the result is a plot of tons per hour of circulation. One charge of radioactive beads lasts for several months. Figures 5 and 6 depict this equipment.

In a system somewhat similar to that for determining catalyst circulation, a radioactive oil soluble compound is followed rather than radioactive beads. The radioactive oil is injected into a pipeline at the time a product change is made. Geiger tubes mounted on the pipe ahead of the receiving station pick up the gamma rays emitted by the radioisotope and operate a recorder and relay circuit to change valves for the new product or to notify the operator of the coming of the interface. Salt Lake Pipe Line Company pioneered this technique.[9] They use 1 to 5 millicuries of an oil soluble Sb-124 compound.

An injector, developed for this technique as shown in Figure 7, uses two compartment cartridges which contain the radioisotope and a flushing oil to force all of the activity into the line at the time an interface passes. Figure 8 illustrates the receiving station and shows the Geiger tubes mounted in a weatherproof box on the pipe. Figure 9 illustrates the correlation of counting rate to relative quantity of each product. Determination of this curve for any given line permits cutting the interface at the desired point, minimizing degradation of product to slops.

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ACKNOWLEDGMENT

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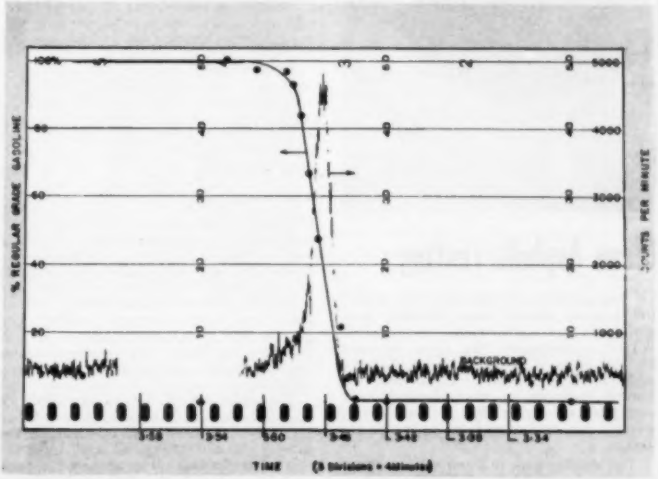


Figure 9. Sharp break in counting rate on the recorder chart indicates the interface of the products. Percentage of displaced product is plotted to show correlation of counting rate to relative quantity of each product.

[How to Do It]

Salvage Tube Turns By This Method

What do you do with the good tube turns attached to condemned tubes? Throw them away probably because it costs too much to recover them by hand.

A welder pocketed $225 through his company's Suggestion Plan by designing the mechanical device shown in the picture at right. The picture tells the story. A welding torch is rigidly mounted adjacent to a rotating table. The table can be raised or lowered by means of threaded rod. The tube turn, attached to a short length of the condemned tube, is clamped to the table and revolved through 360°. A neat, precise cut is made, the tube turn is reclaimed, and you have an economical operation.

The entire assembly will cost about $250 unless you use scrap materials.

Clean Asphalt Testing

This asphalt sink was designed to permit routine gravity and viscosity tests run with as little mess as possible. Added advantages: the time required for the tests is reduced and a disposal problem is eliminated. Equipment required includes a steam-heated sink, steam-traced drain line, steam-heated gravity jar, and a rack to fit inside the sink.

The double sink is fitted with a steam coil between the two sink walls and an inclined bottom to provide good drainage. The drain line is steam-traced to prevent heavy oil from cooling and plugging the drain line. Heavy oil is collected in a drum outside the laboratory and is hauled away to disposal as the drums get full. The gravity jar is made of a 1½-inch pipe inside a 3-inch pipe with the annular space filled with a steam coil made of copper tubing. The gravity jar is equipped with a ¼-inch valve on the bottom to permit draining the oil after the gravity has been checked.

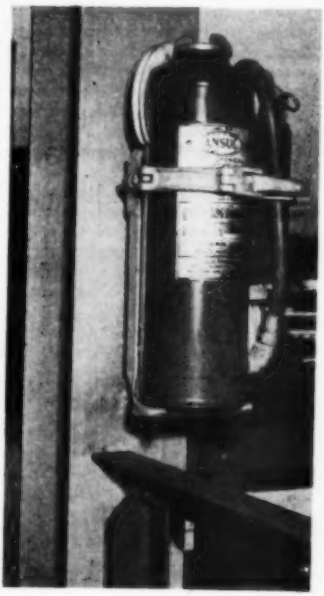
The sink is kept hot so that little or no oil is left in the sink. The gravity jar is heated as needed to measure the gravity of the heavy oil and to drain this oil to disposal. The gravity jar rests on a rack inside the sink; this rack is fitted with a clamp for the hydrometer.

If you don't have a salvaged sink, you'll be out about $40 for materials.

Mount Fire Extinguishers Solidly

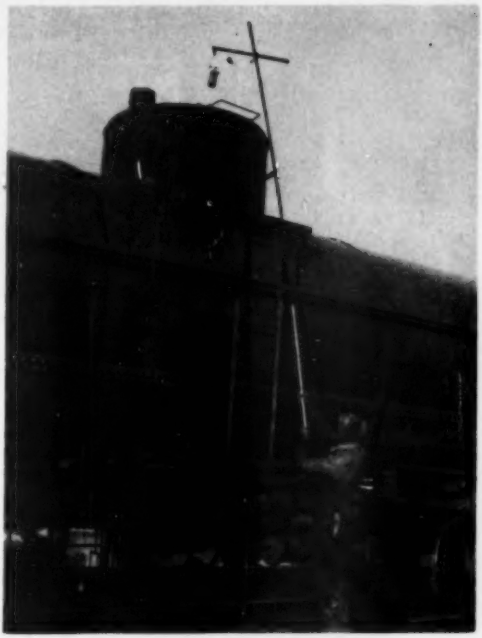
A loosely-mounted fire extinguisher high up in the structure of a process unit is a potential hazard to operating personnel working below. The accompanying picture shows a simple but effective clamp that will insure that the extinguisher is not dislodged as a result of high winds or vibration.

A seat, made from ¼-inch plate, is welded to the structure. The truck type holder is bolted to the seat. The release mechanism on this type holder is easily and quickly operated. It will cost you about $15, including labor, for the complete assembly.

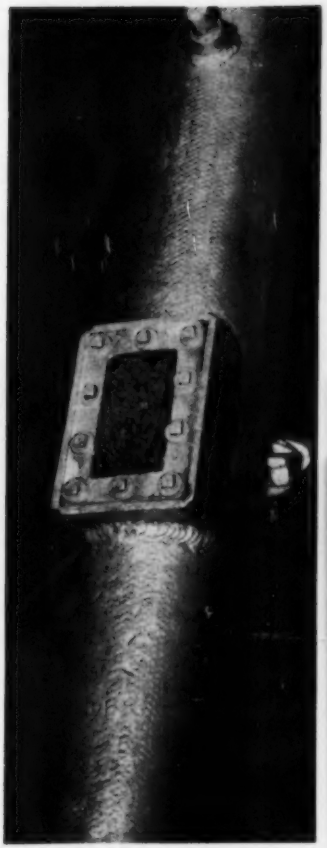


Tank Car Sampling From the Ground

A GAGER has proved that it is easier, safer, and faster to sample tank cars from the ground. The accompanying photograph shows how it is done. The gage pole was constructed in the form of a tee, with one sheave at the bottom and another one at the top. The cage containing the sample bottle was attached to heavy cord. The cord was then drawn through the two sheaves.

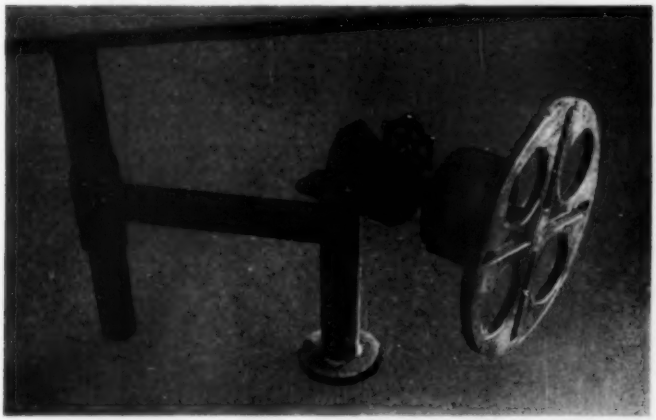


When catching the sample, the cage is drawn snugly against the tee while the pole is guided over the open manhole. The cord is released enough to permit the cage to sink to the bottom of the tank car. Pulling the cord again raises the bottle to the end of the cross shaft and thus the sample is obtained without ever leaving the ground. It may look cumbersome, but this idea has worked well.



Catalyst Look Box

ONE of the big disadvantages in most refinery process equipment is that the operator can not see what is going on inside the lines and vessels. Usually he can rely on instruments to keep him informed, but in one particular instance it was found helpful to provide a "look box." On this cat cracker, fresh catalyst is pressured to the lift engager three times daily. Operators depended on listening with their ear against the pipe to determine when the fresh catalyst was flowing. Of course this is not completely satisfactory so a clear plastic window was installed on the line. The accompanying picture shows the excellent application of the device. The window has been in service for several months without appreciable scratching of the plastic service.



Disappearing Welding Jig

SHOP space is always at a premium. The little welding jig shown in the accompanying photograph can be swung out of the way under the work table when not in use. The jig is very useful as a support for the various fittings undergoing welding operations.

The entire assembly is made from scrap 3-inch pipe and ½-inch steel plate. First build the supporting legs by welding the pipe sections, sized to your requirements. A discarded flange is useful as a foot to support the leg nearest the jig. A free-swinging ferrule is used to join the assembly with the leg underneath the work bench.

The jig plate is made by cutting circular sections from ½-inch plate. The horizontal member holding the jig has a clamp-type ferrule to serve as a hinge. The jig can be rotated through an angle of about 30° to the desired position.

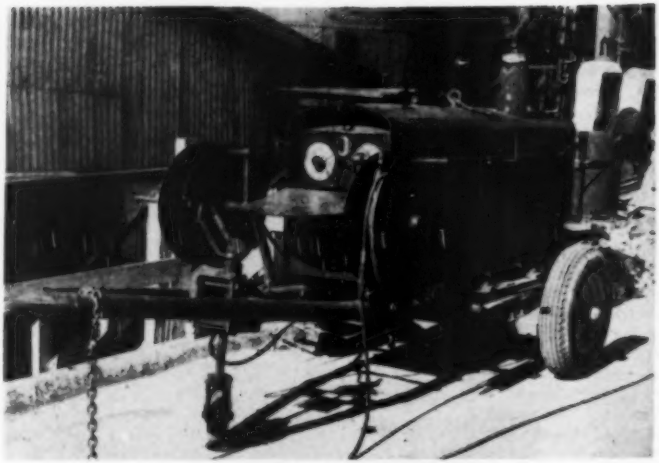
MAINTENANCE / OPERATION

Mobile Welding Set

Use a pickup or tractor to pull the mobile welding set shown in the illustration to any job site. Of course for extra convenience and maximum efficiency, be sure to provide a place on the trailer for any auxiliary tools that may be required—such as rods, chipping hammers, masks, etc.

A particular useful innovation on the assembly pictured is the welding cable reel. The reels are mounted on supports attached to the chassis of the trailer just behind the tongue. The cables are fitted with connections to insure rapid breaking-out or fastening.

The spring-loaded stops on the reels make it possible to use any predetermined length of cable with no danger of slipping. The entire unit can be lifted by a rint attached to the top for loading on a truck for long distance hauling.

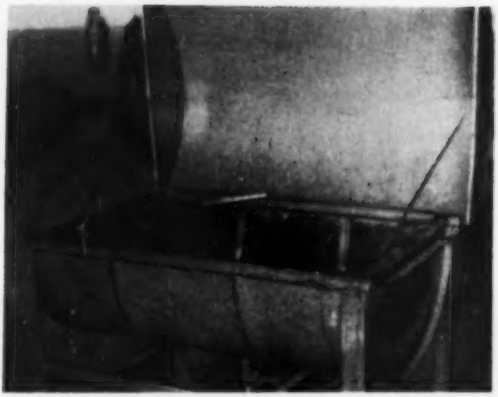


Equipment Washing Tank

Some time and very little money will provide a useful tool cleaning tank. Get together a discarded oil drum, about 30 feet of the ½-inch pipe, and some sheet metal and in a few hours welding time, the tank shown in the illustration will be the result.

The top third of the oil drum is cut away with a torch. Sharp corners and edges are smoothed by tacking on a rim made from ½-inch pipe. A perforated plate is welded into one end to provide a rack for freshly washed tools to drain. A drain pipe and valve are installed in the underneath side of the drum.

To improve the appearance of the tank, you may want to attach a lid made either from sheet metal or from the original top ⅓ of the drum.

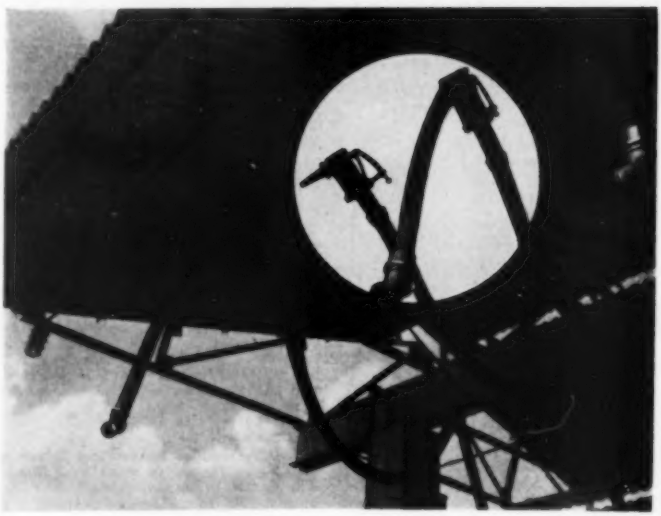


Prevent Evaporation Losses

From both the safety and economy point of view, it is desirable to prevent splashing and foaming when loading gasoline trucks. The accompanying photo shows a very inexpensive but effective way to do just that.

The circled portion of the illustration shows the conventional nozzle (center), with the improved version on the right. The improvement consists simply of a five-foot section of hose with a brass tee on the end, attached to the nozzle. The extension is long enough to allow the tee to rest on the bottom of the tank truck. This eliminates the fire hazard and evaporation losses from the splashing that accompanies loading straight from the nozzle.

It seems mighty simple and you may have already thought of it. If you haven't, you can convert your loading nozzles at a cost of about $10 each.



MAINTENANCE / OPERATION

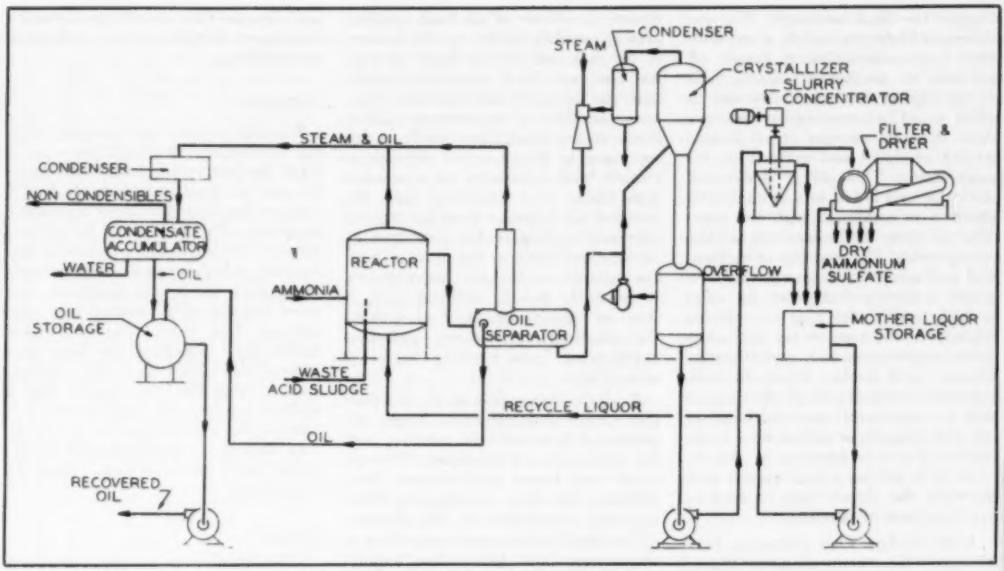


Figure 1. Flow scheme for recovery of ammonium sulfate from acid sludge.

Processing Refinery Waste To Ammonium Sulfate

This method disposes of refinery waste acid sludge and ammonia without causing atmospheric pollution.

Not only is salable ammonium sulfate amounting to 2500 pounds per ton of acid produced but the oil present in the sludge also is recovered.

E. D. Fox
The Fluor Corporation, Ltd.

THE PROCESS for manufacturing ammonium sulfate from waste acid sludge and ammonia varies only slightly from the conventional process using relatively pure sulfuric acid and ammonia. Essentially, ammonia is introduced into sulfuric acid with the resultant formation of ammonium sulfate. The ammonium sulfate is then separated by evaporative crystallization and filtration followed by drying. The available free sulfuric acid in acid sludge will react with ammonia as readily as pure sulfuric acid and therefore acid sludge may be used directly in the process without the necessity of first separating the acid phase from the oil phase. The source of ammonia required for the reaction may be either pure tank car ammonia, or waste ammonia stripped from various refinery streams.

The process described here has been developed by General Petroleum Corporation for application at their Torrance, Calif., refinery where both waste acid sludge and waste ammonia are available for the reaction. The accompanying flow diagram shows the equipment involved and is described below.

Ammonium Sulfate Formation

Acid sludge from various refining processes such as the sulfuric acid treatment of gasoline, stove oil, diesel fuel, etc., is collected in a common storage tank. The storage tank should be of ample size and be equipped with suitable agitation facilities for providing good mixing to give a uniform feed to the process. The acid sludge together with sour stripping steam containing the ammonia are introduced near the bottom of the reactor and flow upward through recycled ammonium sulfate mother liquor and oil from the sludge. The ammonia bearing stripping steam originates at a sour water stripper where various waste streams from the refinery units such as de-cokers, TCC units, vis-breakers, reformers, etc., are steam-stripped of their contaminating hydrogen sulfide and ammonia before disposal. The ammonia in the stripping steam reacts with the acid in the sludge to form ammonium sulfate which together with the sludge oil and recycle mother liquor, rises to the top of the reactor from where it overflows to an oil separator.

Steam and hydrogen sulfide, free from ammonia, pass overhead out of the reactor to a condenser where the steam is condensed out and separated from the uncondensed hydrogen sulfide in a condensate accumulator. The condensate contains a small amount of absorbed hydrogen sulfide and is therefore recycled back to a sour water

stripper for final treatment. The uncondensed hydrogen sulfide, along with other non-condensibles, is drawn off and sent to another processing unit for subsequent catalytic conversion to sulfur in a Claus-type sulfur recovery plant. A small amount of oil is also carried overhead and collects in the accumulator. This oil is drawn off batchwise and is fed to a storage tank where it is combined with the separated oil from the ammonium sulfate-oil separator. The reaction of sulfuric acid and ammonia to give ammonium sulfate is highly exothermic. In order to fully utilize the heat of reaction released in the reactor for the subsequent evaporation and crystallization process, cold mother liquor in sufficient quantity to absorb all the reaction heat in continuously recycled from the tail end ammonium sulfate filter to the reactor. The sole function of this recycle is to act as a heat carrier and, therefore the recycle rate is fixed by available heat of reaction.

Acid sludge and ammonia feed streams to the reactor are proportioned so as to maintain a sulfuric acid concentration of about 0.5 percent in the ammonium sulfate liquor leaving the reactor. This concentration assures relatively complete utilization of the available ammonia and also promotes large crystal formation in the subsequent crystallization step. If a deficiency of either acid sludge or waste ammonia exists, the deficiency may be made up by adding either white acid or tank car ammonia as required to bring the feed to the reactor into stoichiometric balance.

It is desirable to operate the reactor at about 7 psig, since by doing so, the ammonium sulfate liquor will flow from the reactor and through the separator into the crystallizer without intermediate pumping. At this pressure, the temperature of the ammonium sulfate solution, when nearly saturated, will be about 243 F. It is not advisable to operate at a much higher pressure and corresponding temperature since ammonium sulfate corrosion is greatly accelerated by increased temperature.

Oil Separation

The mixture of ammonium sulfate liquor and oil continuously flows from the reactor overflow nozzle into a separator tank where sufficient residence time is provided to permit gravity separation of the oil phase from the ammonium sulfate liquor. The liquor, by virtue of its high specific gravity, readily settles to the bottom of the tank and the oil floats on top. An interface level controller maintains the liquor-oil interface and regulates the flow of ammonium sulfate liquor to the crystallizer. Oil from the separator is discharged through a second level controller to a storage tank where it is combined with the distilled oil collected from the reactor overhead condensate. The combined oil streams collected in the storage tank are suitable for fuel oil. Since the oil is relatively free of sulfuric acid, it may be readily used as fuel without the resultant atmospheric pollution experienced from burning untreated acid sludge.

It is significant to note at this time that some difficulty has been experienced in commercial practice with the separation and handling of the oil from very heavy acid sludges. This difficulty has been overcome by diluting with a light fuel oil. The dilution oil is added to the acid sludge feed at the reactor inlet. Other than making the separated oil more readily handled, no changes in the operating characteristics of the process are effected.

Crystallization

Ammonium sulfate liquor from the separator, at approximately 243 F., is introduced into an evaporative crystallizer where concentration and subsequent crystallization of the product ammonium sulfate takes place by evaporative cooling. It is of interest to note here that when the sulfuric acid concentration in the feed acid sludge to the reactor exceeds approximately 30 percent, process variables such as reactor temperature, mother liquor concentration, recycle mother liquor to the reactor, and crystallizer temperature can be held within practical limits such that no additional evaporative heat is required at the crystallizer. When operating under these conditions, the crystallizer will operate at approximately 150 F. and 3 psia. The vacuum is maintained in the crystallizer by controlled condensation of evaporated water in either a direct contact or surface condenser and a steam jet ejector for removing non-condensible gases. If the acid sludge feed concentration is not suitable for adiabatic operation of the process, then it is necessary that the crystallizer system be provided with a heater of adequate capacity for supplying the necessary heat of vaporization. It is good practice to provide a heater for control purposes even though the system will operate adiabatically. The crystallizer should be of a type that will permit optimum crystal growth and classification in order to facilitate subsequent filtration drying, and product handling.

Filtration

Finished crystals are pumped from the crystallizer in slurry form to a filter. An intervening slurry concentrator may be used to reduce the liquid load on the filter, but is not absolutely necessary. The filter may be of any conventional design; however, ammonium sulfate crystals when crystallized under the proper conditions, are most economically handled in a centrifugal type filter. The perforated basket type centrifuge has been very successfully used for this service. Liquor from the filter drains into a mother liquor tank from which it is pumped back to the reactor as recycle. The recycle is supplemented as required with saturated liquor from the crystallizer.

Drying

The ammonium sulfate cake from the filtration operation is then dryed. Since ammonium sulfate decomposes on excessive application of heat, it is the usual practice to dry the crystals in one of the conventional hot air dryers. Successful application of a combined centrifuge and hot air drier has recently been experienced for this service in a commercial installation. It is necessary that the moisture content of the dried crystals be kept below 0.12 percent in order to prevent difficulties with caking during handling and storage. It is usual practice to dry to approximately between 0.05 and 0.08 percent moisture.

Product Handling

Dried ammonium sulfate is conveyed from the drier to either loading or storage facilities. Any of the conventional conveyors are suitable for handling the product. Pneumatic conveyors have proven very satisfactory in this service where adequate precautions are taken to keep moisture out of the system. Ammonium sulfate is used almost entirely as fertilizer and therefore sales are highly seasonal, consequently, large storage facilities are usually required. Bulk storage facilities are usually provided as they are more economical than package storage facilities. Product ammonium sulfate is sold in either bulk or customary 100-pound bags.

Material of Construction

All process streams are corrosive in nature and therefore careful consideration must be exercised in selecting the materials of construction.

Type 316 stainless steel has proven satisfactory in ammonium sulfate handling and satisfactory service may be anticipated in the use of this alloy for all vessels, process equipment, and piping involved. When using chromium nickel steels in this corrosive service, however, it is important to remember that they are subject to carbide precipitation under certain conditions on the application of heat. Welding produces these conditions and past experience has shown that if proper welding techniques and heat treatment are not adhered to, corrosion difficulties will be encountered.

Carbon steel has proven satisfactory for handling of acid sludge and may be used for storage vessels, pumps and piping in this service. The stainless steels are somewhat more corrosion resistant, but since the oil in the acid sludge apparently inhibits attack from the contained acid to a considerable degree, and corrosion of carbon steel is not severe, it is doubtful whether or not they could be economically justified for this service. Carbon steel is also satisfactory for the reactor overhead condenser, condensate accumulator and associated piping and pumps. However, no brass, bronze or other copper bearing alloys should be used in this service when hydrogen sulfide is present as they would readily be attacked.

Equipment

General Petroleum Corporation has installed and successfully operated for more than one year, a 12-ton per day plant using the process described. The plant is designed to operate with an acid sludge feed stock containing about 41 percent sulfuric acid, 14 percent water and 45 percent oil. The ammonia feed is a foul steam containing about 2 percent ammonia, 2 percent hydrogen-sulfide and the rest water vapor. Design and construction of the plant was handled by The Fluor Corporation in close cooperation with General Petroleum Corporation who furnished all research and pilot plant data for the process. The equipment installed in the General Petroleum plant is described in the following and is more or less typical for this kind of installation.

Reactor

The reactor is a vertical vessel with a height to diameter ratio of 2:1 and having approximately 10,000 gallons liquid volume plus several feet of free space for vapor disentrainment. The large liquid volume is provided to allow for sufficient reaction time and to minimize the effect of variations in feed stream composition and quantity with the end result of holding the composition of the reactor product stream constant. Of particular significance in this respect is the control of acid concentration, since this variable has a marked effect on subsequent crystal formation and overall plant recovery. High acid concentration also results in accelerated corrosion throughout the plant. Both acid sludge and recycle liquor are introduced through separate nozzles located in and near the center of the bottom head. The acid sludge nozzle projects a short distance inside the vessel so that fresh acid sludge feed is discharged away from the vessel wall and is flushed upwards by the recycle liquor. The result is that corrosion resulting from high acid concentration is practically eliminated. Inspection of the reactor after more than one year of service shows that no apparent corrosion has taken place except at the terminal end of the sludge inlet pipe. Corrosion at this point has been rather severe but is of little consequence since the inlet pipe is easily replaced.

The ammonia bearing steam is introduced through four nozzles equally spaced around the circumference of the vessel and located a short distance above the bottom. No special provisions are included for distributing or mixing the steam since sufficient agitation is provided by the thermal circulation resulting from the chemical reaction. Product liquor, oil and recycle liquor leave the reactor through a single overflow nozzle located a few feet from the top head. Stripped steam, hydrogen sulfide and other non-condensibles are discharged through a nozzle in the top head. The reactor operating pressure is controlled by a back pressure regulator on the steam outlet. Liquid flows to the reactor are metered with rotameters and sour steam with an orifice meter. No other instrument controls are provided. Proper concentrations are maintained in the reactor by hand control of the various streams. Convenient sample points are provided on the reactor for routine testing.

The reactor overhead condensers are open-type cooling tower sections followed by a condensate accumulator fitted with a level controller for continuous draw-off. Any oil that is vaporized and carried overhead collects on top of the water and is drawn off batchwise as required. Uncondensed hydrogen sulfide and other gases flow continuously from the accumulator for subsequent processing.

Oil Separator

The ammonium sulfate liquor-oil separator following the reactor is a small diameter horizontal vessel designed to give about one half hour residence time for separation of the two liquid phases. The ammonium sulfate liquor settles to the bottom and the oil floats on top. The vessel is provided with an interface level controller for regulating the continuous draw-off of liquor and a second level controller for regulating the oil flow. In order to take advantage of the available pressure due to the static head of the liquid in the reactor, the oil level controller is located on a standpipe installed on top of the separator and extending above the reactor liquid level. The oil level is maintained at the same height in the standpipe as the reactor liquid level. With this construction, a small diameter, horizontal separator having a relatively large interface for the separation can be used and the advantages of utilizing all the available static pressure and keeping the separator near grade level for ease of operation are still maintained.

Crystallizer

The crystallizer is a Struthers Wells Krystal Crystallizer. This type crystallizer has a vaporizing chamber where excess water is flashed off, and a crystal suspension container which holds the saturated liquor and ammonium sulfate crystals. The vaporizing section is connected to the suspension container by a barometric leg and circulating line fitted with a pump. The vaporizing section operates at about 3 psia and the suspension container remains at atmospheric pressure. Ammonium sulfate liquor from the oil separator is introduced into the crystallizer circulating line where it mixes with recirculated liquor from the suspension container before being introduced into the vaporizer. The circulating line is fitted with a steam heater which supplies any additional required heat for the subsequent vaporization. As previously mentioned, when the feed liquor is at the proper temperature and concentration, this heater is not required, however, it is convenient for control purposes and plant start-up. The liquor passes into the vaporizer where excess water is flashed off by virtue of the reduced pressure and then flows down the barometric leg to the suspension container where ammonium sulfate crystallizes out. Crystal size is largely regulated by the circulation rate. Water removed in the vaporizer is condensed in a water cooled surface condenser and non-

condensible gases are removed by a single steam jet ejector.

Centrifuge and Dryer

The centrifuge is a Baker Perkins "ter Meer" continuous centrifugal and drier combined. The centrifuge consists primarily of a horizontally disposed shaft with a perforated cylindrical basket on one end. The basket is covered with a screen which holds the crystals but permits the liquor to pass through. The shaft is hollow and accommodates a hydraulically operated pusher which reciprocates back and forth in the basket. The basket rotates at about 1600 rpm. The crystal slurry is introduced at the shaft end of the basket and the solids collected on the screen are advanced along the basket towards the open end by the pusher. As the crystals move along the screen, they are given a water wash before final dehydration. The washed and centrifuged crystals fall from the basket into a dry housing where they are intimately contacted with heated air which dries them to about 0.05 percent moisture, and then out through a solids discharge to a product hopper. The drying air is heated by indirect contact with hot oil in an externally located heater and is circulated into the drying chamber by means of a small blower.

Storage Facilities

Storage facilities consist of a five-ton capacity hopper located below the centrifuge and a 30-ton concrete storage bin located several hundred feet from the plant. The five-ton hopper is equipped with a motor driven rotary valve and functions as feed storage for a pressure type pneumatic conveying system which transfers the product to the 30-ton storage bin. The pneumatic conveyor consists of a positive displacement air blower located at the storage bin, conveying pipe, return air pipe, dust filter and a cyclone-type receiver equipped with a bag filter. Crystals fed to the conveyor by the rotary valve are conveyed by circulating air from the blower through the conveying pipe to the receiver where they are discharged into the storage bin. The conveying air is returned to the suction of the blower after passing through the dust filter. The storage bin is so designed that trucks can be driven under and gravity loaded without additional handling.

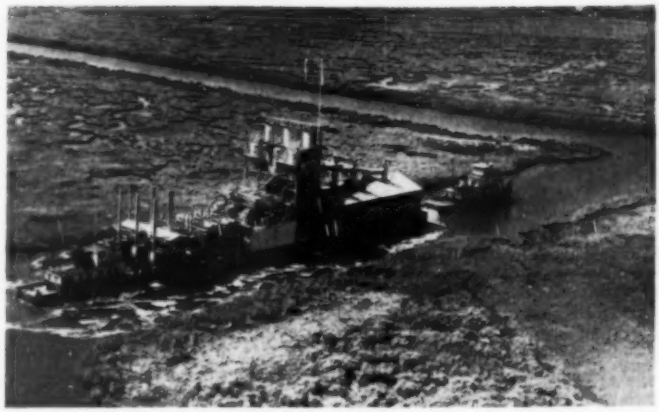
Pumps

There are only three pumps operating in ammonium sulfate service. These are the crystallizer circulating pump, centrifuge slurry feed pump, and filter to reactor recycle pump. They are all motor driven, low head, centrifugal pumps.

Additional pumps are required for handling the feed sludge to reactor, separator oil discharge and reactor overhead condensate return. These are all simplex, double acting, steam driven reciprocating pumps and are of cast iron and mild steel construction with stainless steel fittings.

Piping

Piping is conventional for refinery piping except that connections for flushing water are supplied to all lines where clogging from crystal formation can take place. Since clogging is apt to take place whenever operations become upset, it also is good design to provide flange connections at frequent intervals for ease of removal and cleaning.



Floating Sulfur Mine

With this unique plant, built atop a 200-foot steel barge, Freeport Sulphur Company will mine a sulfur deposit at Bay Ste. Elaine in the Louisiana marshland. Costing more than $2 million, it is the answer to the problem of extracting sulfur needed to make fertilizer, chemicals and other items in an area where the cost of building a permanent plant would be prohibitive. To mine the sulfur, Freeport will use sea water, an innovation made possible by a process perfected by the company. Production is scheduled to begin the latter day of October.

Economic Consideration

The process described in the preceding not only has the advantage of eliminating a disposal problem confronting many refiners, but also converts formerly wasted materials to usable products thus helping to conserve our natural resources. At the same time, the refiner is presented with a new source of revenue. Not only is salable ammonium sulfate amounting to 2500 pounds per ton of 100 percent sulfuric acid (based on 95 percent recovery) produced, but also the oil present in the sludge is recovered. The ammonium sulfate has a market value of about $45 per ton, carload basis, fob works, and the oil will have a minimum value equivalent to plant fuel oil. The characteristics of the recovered oil will of course, be dependent on the refinry crude charge stock. In some cases, oils having higher values may be isolated if the separation costs are not excessive and a market is available.

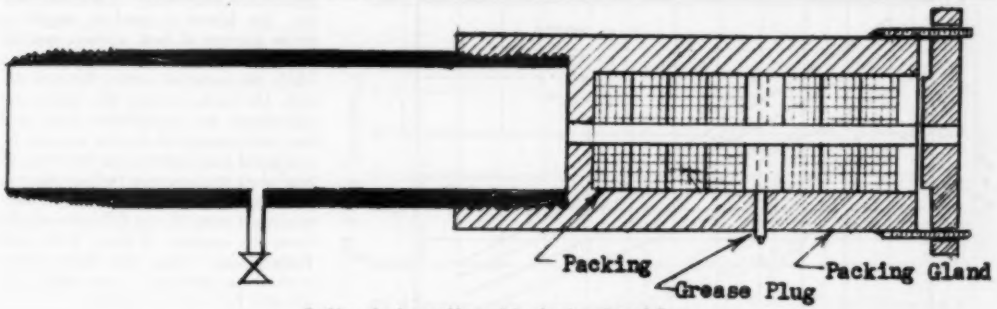
In cases where byproduct ammonia, originating from catalytic refining of high nitrogen crudes, is not available, tank car ammonia at about $75 per ton can be used. Five hundred and fifteen pounds of anhydrous ammonia will be required per ton of ammonium sulfate produced, making the raw material cost about $19 per ton. Utility costs are nominal since only a small amount of power is required for the low head pumps and the product handling equipment. Some cooling medium is required for condensing the reactor and crystallizer overhead, and some fuel is required for providing the necessary heating for product drying.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to General Petroleum Corporation and to the Fluor Corporation, both of whom have made all information in their files relative to the subject available for this paper.

NOTE

Original presentation as "Ammonium Sulfate from Refinery Waste" was at the Petroleum Mechanical Engineering Conference, Kansas City, Mo., September 22, 1952 of the American Society of Mechanical Engineers.



Packing gland assembly used in cleaning plugged lines.

Clean Out Plugged Catalyst With Novel Device

Wayne Rolf and D. W. Caswell
McMurrey Refining Company, Tyler, Texas

WHEREVER CAT crackers are operated, there most certainly will be plugged lines and blocked pressure taps due to hardened catalyst fines. Here is a very useful and ingenious device that makes it possible to clean the plugged lines without losing a single minute of operating time. Briefly, the device consists of a long, hollow lance, fitted to permit the use of live steam as a cleansing agent. The trick comes in the design of the packing gland assembly which makes it possible to use the lance while the unit is in operation.

The packing gland assembly is shown in the drawing. It is fabricated from 2½-inch round carbon steel stock, with ½-inch walls and a seat or packing stop. The packing space is made sufficiently wide to permit the use of adequate packing for high temperature and pressure service. Four alloy studs are welded to the exterior of the gland, and a packing keeper is cut from 1-inch plate. The end of the packing gland is tapped to receive a 1½-inch pipe nipple. This nipple has a ¾-inch valve welded on the side. The packing keeper is designed to accommodate a ⅝-inch drill or lance.

How to Attach Gland

A little preparation is necessary before using the packing gland. First, use a butt weld to attach a coupling to the line that is plugged. The size of the coupling is determined by the diameter of the hole required in the line. Attach a valve to the coupling by means of a short pipe nipple. Now to tap the line, a drill is put through the packing gland and the assembly is attached to the valve on the plugged line. Hook a steam connection to the ¾-inch valve on the pipe nipple and you are ready to drill the hole.

How to Remove Plugged Catalyst

Let's assume that the line is plugged with catalyst. After the hole is made, withdraw the drill, by closing the valve and removing the gland assembly. Insert in the assembly the lance mentioned earlier (this can be ⅜-inch hydraulic tubing, with a steam connection on one end). Return the assembly to its place on the plugged line, open the valve, and start steam through the lance. The steam jet serves to loosen the packed catalyst by acting as a cutting agent. An additional function is to act as a coolant so that the metal lance retains its strength. You will find many applications of the lance around cat crackers: to free plugged pressure taps, remove catalyst from dip legs on cyclones, and to clean catalyst slurry lines. Tremendous savings in catalyst and operating time have been realized from these applications.

How to Clean Lines Plugged With Coke

To free lines that have been plugged with coke, the same drill used in providing the mount for the packing gland is used to drill out the coke. After a hole has been drilled through the coke deposit, steam is used to blast out the loosened coke into blowdown lines or vessels. This removes the obstructions to a key instrument or control valve. When this operation is performed, a drill with a very long shank may be required. This can be made by attaching a piece of ⅝-inch round stock to the standard size drill. You are likely to find applications for this technique in vis-breakers, vacuum distillation units, and thermal crackers.

It may cost about $150 to build the packing gland assembly. Your money will be returned many times as it is used to free coke and catalyst plugs, attach emergency lines, or in making hot taps. And the process unit can go right on operating!

MAINTENANCE / OPERATION

Process Reprint Ready

Because of the unprecedented demand for 1) the Process Section and 2) the Marshall Sittig article "Catalytic Cracking Techniques in Review," features of our September issue, PETROLEUM REFINER has reprinted the two in a single booklet.

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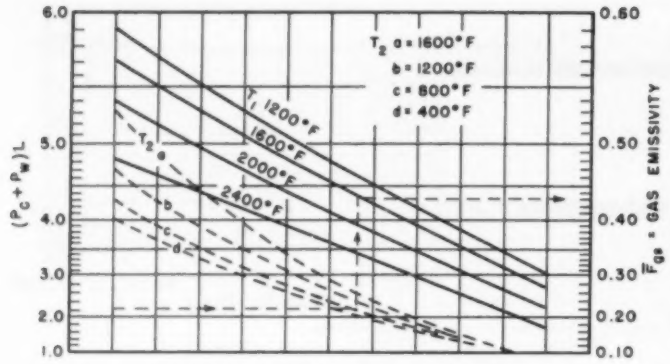

Figure 9. Gas Emissivities (after Lobo and Evans).

Evaluation of Radiant Heat Absorption Rates in Tubular Heaters

Part II. How to handle reradiation and total radiation problems. Rate of total radiant heat absorption by individual banks is easily calculated.

L. A. Mekler[1] and R. S. Fairall[2]

THIS ARTICLE is intended to present simplified working equations, curves and methods for evaluating direct radiation from gases and reradiation from refractories to different tube banks of a heater, so that rates of total radiant heat absorption by the individual banks can be derived. The values obtained by the procedures described are approximate, but sufficiently accurate for practical purposes and are within the range of value which can be obtained by test with instruments and methods used for commercial testing of tubular heaters.

Radiant heat absorption characteristics of different types of heaters are determined by the geometry of the heater which affects the direct radiation from the gases and particularly the reradiation from the bare refractories of the heater envelope. Not only are these characteristics different for the different types, but the characteristics of the different banks in a particular heater may vary considerably with their location in the heater and the angle through which the banks "see" the refractories. In some heaters total reradiation to one of the banks is almost double the reradiation to the other banks with the result that the total radiation to the banks is sufficiently different to affect the character of the thermal treatment received by the material as it passes through the banks.

On some services such as reboiling, preheating to below the reaction temperature, superheating of heat carriers, etc., the heater is used to supply a given amount of heat without specific requirements as to the rates of heating while the material passes through the coil. On such services the heater requirements are quantitative only, and the performance of the heaters can be evaluated satisfactorily on the basis of total duty and average radiant absorption rates provided the maximum and minimum rates do not differ too widely from the average. Wilson, Lobo and Hottel, and Lobo and Evans have worked out methods, particularly applicable for such evaluation.

There are many processes sensitive to rates of heating, where the heater has to meet not only quantitative requirements but also must have certain qualitative characteristics as to rates of heat input while the material travels through the coil, to produce a desired time-temperature relationship, or "heating curve." The requirements of a large number of such processes can be met in heaters with substantially uniform rates of heat input, provided the rates are uniform. Some processes require higher rates at the beginning of the coil, some towards the end of the coil, while occasionally a process may require much lower than average rates in an intermediate section of the coil, usually where a liquid material goes through a change of phase and because a viscous foam with a low conductivity, which may be overheated, unless the rates applied to the material while it is a foam are considerably lower than the rates on both sides of this section.

Where a heater is used on a process sensitive to thermal treatment, the different tube banks must be evaluated separately to make sure that any significant variation in rates to the different banks does not affect adversely the desired time-temperature relationship through the coil. For example, in floor-fired cellular heaters with long tube banks along the roof and both walls the theoretical radiant heat transfer rates to the roof bank may be appreciably higher than the rates to the wall banks. In addition, when the gases leave through the roof bank, which is common with such heaters, the roof tubes receive additional heat by convection from the gases flowing over them so that with high rates of flow of high temperature gases over the roof tubes the total heat input rates to the roof banks may be 30-40 percent higher than to the wall banks which are radiant banks only. If the heat requirements per degree temperature rise of the material heated increase with temperature and the process requires a relatively steep heating

Part I appeared in June, 1952 issue of Petroleum Refiner, page 181.

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curve towards the end, the roof bank of this heater should be the last path of the material through the heater. If a heating curve with a long relatively flat section at the end is required, the flow should be first through the roof tubes and then through the wall tubes in series. A flow first through one wall bank, then through the roof bank and out through the other wall bank will give a heating curve with a steep portion in the middle of the radiant coil.

Direct Radiation from Gases

Gases radiate in all directions and the gas particles can be considered as centers of spheres radiating to the surface of the sphere by beams equal to its radii with an emissivity which is determined by the composition of the gases and the length of the radius. The enclosures of commercial heaters are not spherical, but are made up of plane or cylindrical surfaces. Radiation from the gas particles to such enclosures is by beams of different length which fall upon the surfaces of the enclosures at different angles so that the final emissivity of the gas to the enclosures is determined by the composition of the gases and the geometric configuration of the enclosures, which determines the "mean" beam. The mean beam is a beam of such length that if directed at right angles to the bounding surfaces of the enclosure it would have the same effect as the average of all the beams directed to the surfaces at their respective angles. Values for lengths of mean beams of gas radiation, L, have been worked out for a number of enclosures by Hottel and co-workers. The values in Table 3 have been accepted as good approximations for the shapes of heaters most commonly used.

TABLE 3

Mean Lengths of Beams for Gas Radiation

Shape and Dimension Ratios	Length of Beam, L
Chambers Heaters:	
1 x 1 x 1 to 1 x 1 x 3 1 x 2 x 1 to 1 x 2 x 4	$\frac{3}{2}\sqrt[3]{\text{volume}}$
1 x 1 x 4 to 1 x 1 x ∞	Smallest dimension
Cellular Heaters:	
1 x 2 x 4	$\frac{3}{2}\sqrt[3]{\text{volume}}$
1 x 2 x 5 to 1 x 2 x 8	1.5 smallest dimension
Cylindrical Heaters:	
d x 2d to d x ∞l	Diameter of cylinder

Products of combustion of hydrocarbon fuels contain N_2, CO_2, H_2O, O_2, small amounts of SO_2 with fuels containing sulphur, and usually no CO. Only the heteropolar gases (CO_2, H_2O and SO_2) emit and absorb radiation. Gases with symmetrical molecules (N_2, O_2 and CO) are "transparent" to radiation, that is, they do not show absorption spectra in those wave lengths which are of importance in industrial heaters. The emissivities due to heteropolar gases are additive and the "net" emissivity of the gases to the surroundings, $\overline{F}_{gs}$, is the difference in the emissivity of the gases at their temperature T_1, $\overline{F}_{gt_1}$, and the absorbtivity of the gases at the temperature of the surroundings. At the temperatures encountered in commercial heaters the absorbtivity of the gases can be assumed as equal to their emissivity at the same temperature, or

$$\overline{F}_{gs} = \overline{F}_{gt_1} - \overline{F}_{gt_2}$$

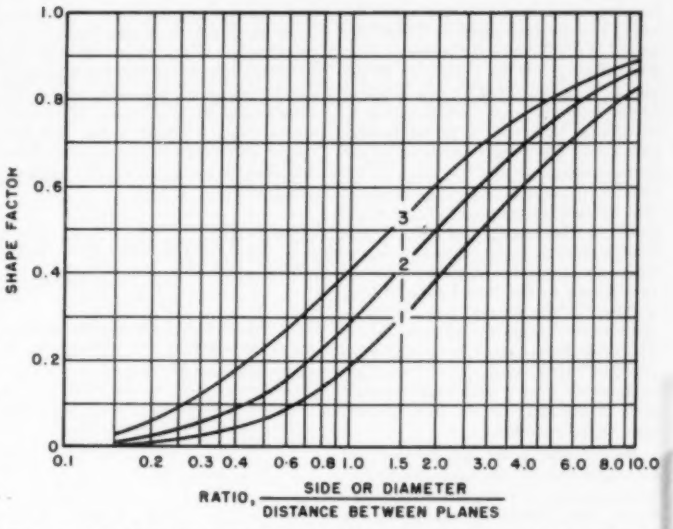


Figure 10. Shape Factor for Parallel Rectangles (after Hottel). 1—Squares. 2—1x2 rectangles. 3—Long narrow rectangles.

H_2O has a higher emissivity than CO_2 at the same temperature and beam length. As shown in Figures 1 and 2, products of combustion from gaseous fuels have a higher ratio of H_2O to CO_2 when burned with the same amount of excess air and therefore, with nonluminous firing, have a higher emissivity than combustion products of liquid fuels. However in actual firing the flames from both fuels are partly luminous and the oil flames are normally more luminous than gas flames. Corrected for luminosity, the emissivity of products of combustion from both fuels with equal contents of heteropolar gases is substantially the same.

Figure 9 gives average values of emissivity of combustion gases as a function of their CO_2 and H_2O content and length of mean beam $(P_c + P_w)L$, for different T_1 and T_2. The emissivity due to SO_2 is close to that of H_2O so that with the small amounts of SO_2 usually present it can be added to that of H_2O for the value of P_w. The values in Figure 9 include an added correction for luminosity of average gas and oil flames obtained with average good firing, that is, with clear lavender-blue gas flames and sharp orange-yellow oil flames. The correction varies from 0.08 to 0.13, depending on the temperature of the gases and their composition. An example for a procedure to obtain the emissivity of combustion products from burning a gas fuel, as per Figure 1, with 30 percent excess air is shown on the figure.

From Figure 1,

$$P_c = \frac{\%CO_2}{100} = 0.09;\ P_w = \frac{\%H_2O}{100}$$
$$= 0.125;\ P_c + P_w = 0.215.$$

In a heater with a mean beam of 10 ft., $(P_c + P_w)L = 2.15$. With $T_1 = 1600$ F. and $T_2 = 800$ F., the gas emissivity is 0.43.

As can be seen from Figure 9, the emissivity of gases is affected only slightly by changes in T_1 or in T_2. For example, if T_1 is 2000 F. or 1200 F. instead of 1600 F. used in the example, with T_2 and $(P_c + P_w)L$ remaining the same, the emissivities will be 0.39 and 0.46 respectively. A change in T_2 is even less effective, the emissivity changing to 0.44 for $T_2 = 400$ F. and to 0.42 for $T_2 = 1200$ F.

Reradiation

If commercial tubular heaters had all surfaces of the furnace envelope covered by tube banks, the radiant

heat supplied to the banks would be only by direct radiation from the gases. With T_1 and T_2 assumed uniform throughout the emissivity of the gas as obtained from Figure 9 would be the total emissivity and the same to all banks. However, in actual heaters tube banks cover only a portion of the furnace envelope and the ratio of the area of the tube banks to the areas of the furnace envelope or "cold fraction" of the heaters vary from less than a third to more than two-thirds. The bare surfaces of heaters act as reradiators to the tube banks of that portion of the radiant heat which is not absorbed from the gases by direct radiation. In heaters with a small cold fraction, reradiation from the bare surfaces is a very important component of the total radiant heat absorption by the tube banks.

Reradiation from refractories can be expressed by the same basic formulae as used for direct radiation between two planes by considering reradiation as a result of two simultaneous mechanisms—radiation from gases to refractories, and radiation from refractories to the cold surfaces.

Radiation from gases to a refractory is

$$Q_{gr} = .173\ A_r \times \overline{F}_{gr} \times \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_r}{100}\right)^4\right] \quad (9)$$

Where

Q_{gr} = the amount of radiant heat received by the refractory
A_r = the area of the refractory
$\overline{F}_{gr}$ = the emissivity of the gases to the refractory
T_1 = gas temperature °R, and
T_r = refractory temperature °R

Total radiation from a refractory at a temperature T_r to a number of cold surfaces at temperatures T_2 is

$$Q_{rs} = Q_{rI} + Q_{rII} + \ldots$$

$$Q_{rs} = 0.173 \times [F_{rI}A_I + \overline{F}_{rII}A_{II} + \ldots] \left[\left(\frac{T_r}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \quad (10)$$

Where

Q_{rs} = total heat radiated by a refractory to all cold surfaces
$Q_{rI}, Q_{rII}, \ldots$ = heat transferred from the refractory to individual cold surfaces with areas $A_I, A_{II}, \ldots$
and
F_{rI}, F_{rII} = shape factors between area of the refractory and $A_I, A_{II} \ldots$

In actual heaters the refractories receive heat from the gases by convection as well as by radiation so that potentially the available radiation from the refractory to the cold surfaces, Q_{rs}, as given in Equation (10), is greater than the heat absorbed by the refractories from the gases by radiation only, Q_{gr}, as given in Equation (9). However, except for specific refractory surfaces in some types of heaters, as discussed later, the main body of gases does not "wash" the refractories of the heater at any appreciable velocity so that the relatively small amount of heat supplied to the refractories by convection is usually assumed to be equal to the heat lost by the refractory to the outside. With this assumption, Equation (9) becomes equal to (10), and

$$\left(\frac{T_r}{100}\right)^4 = \frac{[A_I\overline{F}_{rI} + A_{II}\overline{F}_{rII} + \ldots]\left(\frac{T_2}{100}\right)^4 + A_r\overline{F}_{gr}\left(\frac{T_1}{100}\right)^4}{A_I\overline{F}_{rI} + A_{II}\overline{F}_{rII} + \ldots\ldots + A_r\overline{F}_{gr}} \quad (11)$$

Heat transfer to any single surface, A_I, from a refractory surface, A_r, is

$$Q_{rI} = 0.173 \times A_I\overline{F}_{rI} \times \left[\left(\frac{T_r}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \quad (12)$$

Substituting (11) in Equation (12)

$$Q_{rI} = 0.173 \times A_I\left[\frac{\overline{F}_{rI}A_r\overline{F}_{gr}}{A_I\overline{F}_{rI} + A_{II}\overline{F}_{rII} + \ldots A_r\overline{F}_{gr}}\right]\left[\left(\frac{T_1}{100}\right)^4 + \left(\frac{T_2}{100}\right)^4\right] \quad (13)$$

The first bracketed in term is the combined emissivity of A_r to A_I, when A_I is one of a number of cold surfaces receiving radiation from the refractory and can be expressed as

$$\frac{\overline{F}_{rI} \times \overline{F}_{gr}}{\frac{A_I}{A_r}\overline{F}_{rI} + \frac{A_{II}}{A_r}\overline{F}_{rII} + \ldots + \overline{F}_{gr}} \quad (14)$$

If the refractory radiates to only one surface A_I, equal in area to A_r, Equation (14) becomes

$$\frac{\overline{F}_{rI} \times \overline{F}_{gr}}{\overline{F}_{rI} + \overline{F}_{gr}} \quad (15)$$

If two equal cold surfaces A_I receive radiation from a refractory with a different area A_r, such as when a floor or an end wall radiate to two equal side walls, Equation (14), becomes:

$$\frac{\overline{F}_{rI} \times \overline{F}_{gr}}{\left[\frac{A_I}{A_r}\overline{F}_{rI}\right] \times 2 + \overline{F}_{gr}} \quad (16)$$

for either side wall.

As shown in Equation (13) radiation from a refractory to a cold surface is expressed in terms involving the temperatures of the gases and of the cold surface, the relative emissivities of the gases to the refractory and of the refractory to the cold surface and the area of the refractory and the cold surface. The temperature of the refractory does not enter into Equation (13) because with the assumption that the refractory receives its heat by radiation only it is not an independent variable, but is at an equilibrium temperature determined by the relationships in Equation (11).

When the refractory is washed by gases at high velocities, or when it contains burner blocks which occupy an appreciable portion of the area of the refractory, the refractory will have a mean effective radiation temperature considerably higher than the equilibrium refractory temperature, T_r, with some parts of the refractory being hotter than the equilibrium gas temperature, T_1. For accurate evaluation of reradiation from such "hot" refractories, their effective radiation temperature can be determined by calculations of a "mean" radiation temperature from equation

$$T_{rm} = \sqrt[4]{\frac{A_1\left(\frac{T_1}{100}\right)^4 + A_2\left(\frac{T_2}{100}\right)^4 + \ldots}{A_1 + A_2 + \ldots}} \quad (17)$$

Where

T_1, T_2, etc. = temperatures of the different sections of the refractory obtained by optical pyrometer and A_1, A_2, etc. = respective areas of the sections at T_1, T_2, etc.

Calculation made on a few operating heaters indicate that T_{rm} may be assumed equal to the equilibrium gas temperature T_1 without appreciable error and with very appreciable simplication of calculation of reradiation from the hot refractories.

The combined emissivity of the cold cold surface due to reradiation from refractories is obtained in two steps:

1) The emissivity of the gas is obtained from Figure 9. This is the fraction of black body radiation which the gas will radiate to the cold surfaces or the refractories. The fraction of black body radiation which is available for reradiation to the cold surfaces from the refractories is $(1 - \overline{F}_{gr})$.

2) The emissivity of the cold surface, A_I, with respect to available radiation, $\overline{F}_{rI}$, is expressed as a fraction, F, of $(1 - \overline{F}_{gr})$, which the cold surface can intercept because of its geometric relationship to the refractory or the "shape factor" of the two surfaces.

The shape factor is the summation of radiant heat interchange between all elements of one surface to all elements of the other surface, taking into

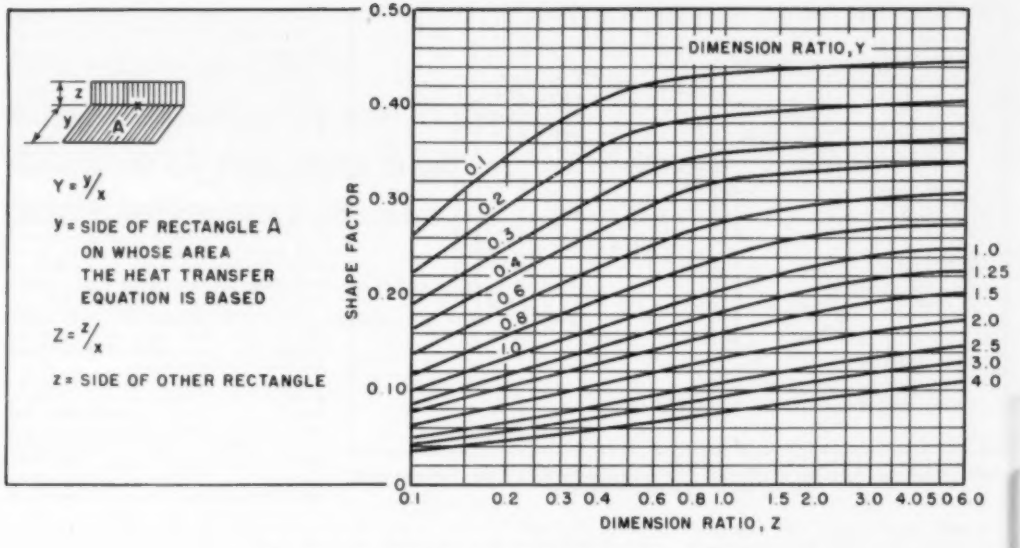


Figure 11. Shape Factor for Perpendicular Rectangles (after Hottel).

account the angles with which the elements "see" each other and the distance between the elements. Figure 10 shows the commonly accepted Hottel-shape factors for opposed parallel rectangles as determined by the dimensions of the rectangles and the distance between them. Figure 11 shows the Hottel-shape factors of rectangles perpendicular to each other. The values obtained from Figures 10 and 11 can be used for rectangles deviating slightly from parallel or rectangular relationships by using projected areas. For example in determining shape factors of slightly inclined planes of roofs or side walls the projected areas of the side walls on a vertical plane and of the roof on a horizontal plane can be used without appreciable error. With deviation more than 20° from rectangular or parallel the shape factor must be determined by integrating the basic relationship

$$\frac{\text{Cos } \phi_1 \text{ Cos } \phi_2 \, dA_1 \, dA_2}{\pi R^2} \qquad (18)$$

Where A_1 and A_2 = the respective areas of the planes, R = distance between centers of A_1 and A_2. $-_1$ and $-_2$ = angles which the normals to A_1 and A_2 make with R. The elements of Areas A_1 and A_2 must be small compared to length of R.

Examples

The following examples illustrate a procedure for determining combined emissivities of cold planes receiving direct radiation and reradiation from refractories. All cases are for a simple parallelopiped 15 x 15 feet x 40 feet with cold surfaces covering the whole area of the sides of the parallelopiped. Gas emissivity is based on $P_c + P_w = 0.21$; beam length of 13.9 feet (from Table 3); $T_1 = 1600$ F. and $T_2 = 900$ F.

Case 1. Cold surface roof only, A_I, Figure 12.

Step 1. Reradiation from Floor $A_{(1)}$ to A_I

(a). Shape factor from Figure 10 and Hottel approximation $F = \sqrt{F_1 \times F_2}$, where F_1 = shape factor for squares with 15-foot side, 15 feet apart, and F_2 shape factor for squares with 40-foot side, 15 feet apart.

$$F = \sqrt{0.20 \times 0.47} = 0.31$$

(b). Relative emissivity between A_I and $A_{(1)}$. $\overline{F}_{rI}$ (in Equation 15) $= (1 - \overline{F}_{22}) \times F = (1.0 - 0.46) \times 0.31 = 0.16$

(c). Combined emissivity gas to A_I via $A_{(1)}$, Equation (15)

$$\overline{F}_{(1)(I)} = \frac{0.16 \times 0.46}{0.16 + 0.46} = 0.12$$

Step 2. Reradiation from each side wall $A_{(3)}$ and $A_{(3)}$ to A_I.

(a). Shape factor from Figure 11:

$$Y = Z = \frac{15}{45} = 0.33 \quad F = 0.27$$

(b). As above

$$\overline{F}_{rI} = 0.54 \times 0.27 = 0.15$$

(c). $\overline{F}_{(3)I}$ or $\overline{F}_{(3)I} = \dfrac{0.15 \times 0.46}{0.15 + 0.46} = 0.11$

Step 3. Reradiation from each end wall $A_{(4)}$ and $A_{(4)}$ to A_I

(a). Shape factor from Figure 11:

$$Y = Z = \frac{15}{15} = 1.0 \quad F \times 0.11$$

(b). As above

$$\overline{F}_{rI} = 0.54 \times 0.11 = 0.06$$

(c). $\overline{F}_{(3)I}$ or $\overline{F}_{(4)I} = \dfrac{0.06 \times 0.46}{0.06 + 0.43} = 0.05$

Step 4. Combined emissivity due to reradiation to A_I

$$\underset{\text{from floor}}{0.12} + \underset{\text{from side walls}}{0.11 \times 2} + \underset{\text{from end walls}}{0.05 \times 2} = 0.44$$

Step 5. Total combined emissivity = $0.46 + 0.44 = 0.90$

Case 2. Roof and floor cold, A_I and A_{IV}. Since each refractory reradiates equally to two cold planes, Equation (16) is used to determine reradiation from each refractory to either cold plane. Taking the roof as the cold plane, shape factors, (a), and relative emissivities, (b), for roof and sidewalls and roof and end walls are the same as in Case 1, and F_{rI} in Equation (16) are 0.15 for end walls and 0.06 for side walls.

Step 1. Reradiation from each side wall to roof, $A_{(3)} - A_{(1)}$ to A_I.

$$(c) = \frac{0.15 \times 0.46}{(0.15) \times 2 + 0.46} = 0.09$$

Step 2. Reradiation from each end wall to roof, $A_{(4)} - A_{(4)}$ to A_I.

The areas of the end walls are not equal to those of roof, and the area factor, $\dfrac{A_4}{A_I} = \dfrac{600}{225} = 2.67$ must be introduced in Equation (16)

$$(c) = \frac{0.05 \times 0.46}{(2.67 \times 0.05) \times 2 + 0.46} = 0.03$$

Step 3. Combined emissivity due to reradiation to roof or floor = $(0.09) \times 2 + (0.03) \times 2 = 0.24$

Step 4. Total combined emissivity = $0.46 + 0.24 = 0.70$.

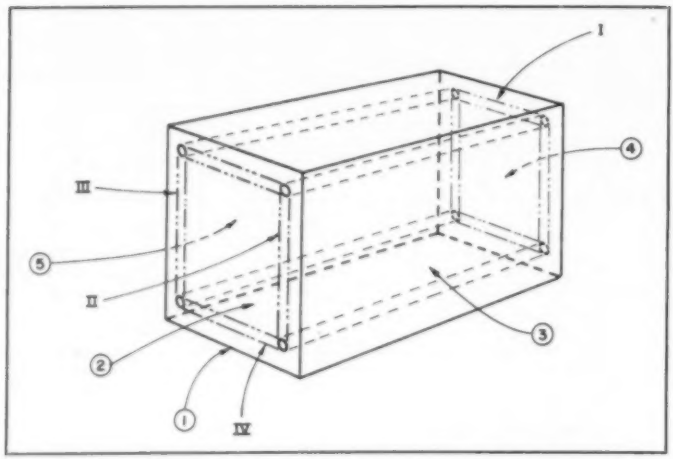


Figure 12. Reference Subscripts for Planes of Parallel-piped in Examples. Roman Numerals—Cold Planes; Arabic Numerals—Refractories.

Case 3. Roof and both side walls cold, A_1, A_{II} and A_{III}. Shape factors, (a), and relative emissivities, (b), same as Case 1.

Step 1. Reradiation from floor to roof.

The floor reradiates to three planes with $F_{rI} = 0.16$ to roof and $F_{rII} = 0.15$ to each side wall. Equation (14) is therefore used, but because the surfaces of the refractory and of the cold planes are equal, the area ratio factors are eliminated.

$$(c) = \frac{0.16 \times 0.46}{0.16 + (0.15) \times 2 + 0.46} = 0.08$$

Step 2. Reradiation from end walls to roof.

Each end wall also radiates to three equal surfaces with an area 2.67 times the area of the end wall. Therefore

$$(c) = \frac{0.06 \times 0.46}{2.67 \times (0.06) \times 3 + 0.46} = 0.03$$

Step 3. Reradiation from floor to side walls

$$(c) = \frac{0.15 \times 0.46}{(0.15) \times 2 + 0.16 + 0.46} = 0.07$$

Step 4. Reradiation from end walls to side walls.

Same as to floor
$(c) = 0.03$

Step 5. Combined emissivity of reradiation to roof $= 0.46 + 0.08 + (0.03) \times 2 = 0.14$, and to side walls $= 0.07 + (0.03) \times 2 = 0.13$, and total combined emissivity to roof and side walls are 0.60 and 0.59 respectively.

Case 4. As Case 3, except the floor is at equilibrium gas temperature, T_1.

Since the floor is at the same temperature as the gases it receives no radiation from the gases and acts as an independent radiator of the available radiation, $(1 - 0.46) = 0.54$, at the same temperature as the gas, with an emissivity equal to the shape factor of the plane of the floor with the planes of the surfaces to which it radiates. The emissivity of the floor to the roof,

$F_{1,I} = 0.54 \times 0.31 = 0.17$ and to either side wall,

$F_{1,II} = 0.54 \times 0.29 = 0.15$. The emissivities of the end walls to roof and side walls are the same as in Case 3, so that the total combined emissivities become

Roof $= 0.46 + 0.17 + (0.03)\ 2 = 0.69$
Side walls $0.46 + 0.15 + (0.03)\ 2 = 0.67$
Average $= 0.68$

The significance of change in emissivities due to different geometric relationship of cold surfaces and reradiating refractories in a given shape of a heater is shown by a comparison of radiant heat absorption rates in the examples above, made with the following assumption for all cases:

Fuel-gas as per Figure 1, burned with 40 percent excess air; flame burst temperature $T_F = 3400$ F.; temperature of cold planes $T_2 = 900$ F.; liberation $Q_3 = 30{,}000$ Btu per hour per square foot of cold plane. Refractories at their equilibrium temperature T_r (Equation 11).

Rates of radiant heat absorption, equilibrium gas temperature and the other comparative values are obtained from Figure 3 in this manner.

Figure 3 is based on gases with emissivity of 0.95, radiating to a "black body" cold surface, so that the total combined emissivity of the gases to the cold surface is 0.95. The combined emissivity of the roof in Case 1 is 0.90. The liberation $Q_3 = 30{,}000$ is therefore equivalent to a liberation Q_3, on Figure 3 of

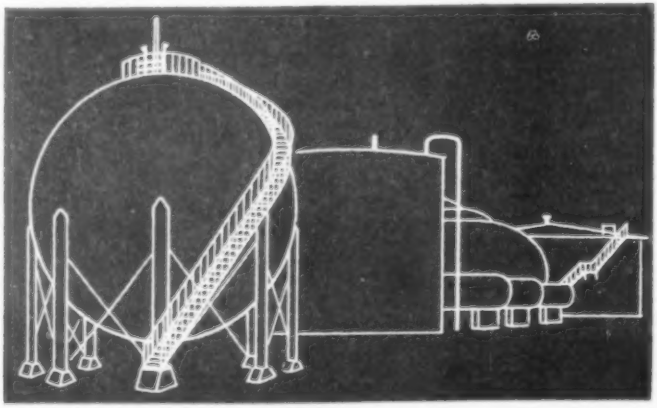
$$\frac{30{,}000 \times .95}{0.90} = 31{,}700.$$

From Figure 3, with a liberation of 31,000 Btu and a flame burst temperature of 3400 F., the absorption per square foot of effective area is $Q_3 = 19{,}500$ and T_1 is 1510 F. The plane of the roof has an emissivity of 0.90, therefore the radiant heat absorption by the roof plane is $Q_4 = 19{,}000 \times 0.9 = 17{,}600$ Btu per hour per square foot of area of the plane. The efficiency of the cold plane of the roof is $\frac{Q_3}{Q_4} = 58.5$ percent.

Similarly, for Case 2, $Q_3 = 40{,}700$; $Q_3 = 23{,}800$; $T_1 = 1600$ F.; $Q_4 = 16{,}700$ and efficiency $= 55.6$ percent, and for Case 3, using the average emissivity for all cold planes 0.593, $Q_3 = 48{,}000$, $T_1 = 1660$ F.; $Q_4 = 16{,}000$ and efficiency $= 53.4$ percent.

End of Part II. Part III, the concluding section, will appear in an early issue.

* * *



New Rapid, Accurate Method for

Determination of Oil Content of Paraffin and Microcrystalline Waxes

As many as 20 or more determinations can be made by one operator in one eight-hour shift.

J. E. Blaylock
Magnolia Petroleum Company
Beaumont, Texas

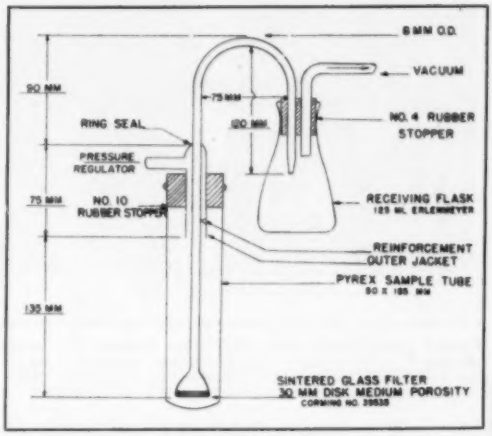


Figure 1. Filter assembly.

A METHOD for determining oil content of both paraffin and microcrystalline waxes which employs an intermediate size sample and combines some of the advantages of each of the two existing methods has been developed and tested in this laboratory. The essential features of the standard method of test are retained in the new procedure but all weighings except one are eliminated on the analytical balance. The simplified procedure permits a large number of samples to be run concurrently thereby greatly reducing the average time per sample.

Two ASTM methods are available for determining the oil content of paraffin wax. ASTM D721-47[1] "Standard Method of Test for Oil Content of Paraffin Wax" employs a 25 gram sample, and ASTM D721-51T[2] "Tentative Method of Test For Oil Content of Paraffin Wax" (semi-micro method) employs a one-gram sample. These ASTM methods give reliable results and are entirely satisfactory as referee procedures, but have certain disadvantages when employed for refinery control work. Method D721-47[1] is time consuming and requires bulky equipment. D721-51T[2] is tedious because of small amounts of material involved and the necessity of frequent use of the analytical balance. No standard method has been developed heretofore for estimating oil content of microcrystalline waxes but several unofficial methods are employed by the industry.

The proposed method is recommended for analyzing waxes having a melting point of 105 F. or higher and containing not more than 15 percent of oil as specified in the ASTM procedure.[3] However, this laboratory applies the same method with excellent results for products of lower melting points and higher oil contents.

Oil present in the paraffin wax is defined as the percent of solvent free residue less a factor of 0.15 which is a correction for the solubility of wax in the solvent. This correction factor was developed empirically on waxes containing known quantities of oil and having melting points between 115 F. and 145 F.[1]

In the past the ethylene dichloride method[2] has been used in this laboratory for estimating the oil content of microcrystalline waxes. Since the oil content is arbitrarily defined as that material which is extracted from the microcrystalline wax by the solvent under the specified test conditions, methylethyl ketone solvent is now used for analyzing the microcrystalline wax. This has the advantage of employing one apparatus and one solvent for analyzing both types of waxes and makes the results obtained on different waxes comparable.

Although the semi-micro method has been retained by this laboratory for referee purposes, the proposed method has been adopted for routine evaluations and the results were found to be in agreement with those obtained by ASTM methods D721-47[1] and D721-51T.[2]

The equipment which is illustrated in Figures 1-4 consists of the following articles:

Wide mouth cylindrical flasks, 50 x 185 mm, to be used as cooling flasks and for preparing the wax solvent mixtures.

Narrow mouth Erlenmeyer flasks of 125-ml capacity for collecting the filtrate and evaporating the solvent.

Filter stick and assembly shown in the picture. The filter stick is made of sintered glass of medium porosity of 30-mm diameter and 210 mm in length. The stick is provided with a delivery nozzle and an inlet tube which acts as a pressure regulator. A stopper fits the mouth of the cooling flask and the delivery nozzle has a stopper to fit the receiving flask.

TABLE 1
Extraction of Paraffin Waxes by Proposed and Semi-Micro Procedures

	PROPOSED														
	Operator A			Repeatability	Operator B			Repeatability	Operator C			Repeatability	General Average	Total Deviations (Repeatability)	Average Deviations (Reproducibility)
	1	2	3		1	2	3		1	2	3				
1	0.18	0.22	0.24	0.06	0.20	0.20	0.23	0.03	0.21	0.21	0.22	0.01	0.21	0.06	0.03
2	0.20	0.24	0.26	0.06	0.18	0.22	0.24	0.06	0.21	0.22	0.23	0.02	0.22	0.08	0.04
3	0.58	0.60	0.65	0.07	0.63	0.68	0.70	0.07	0.64	0.67	0.80	0.16	0.66	0.22	0.14
4	1.10	1.20	1.20	0.10	1.38	1.46	1.56	0.18	1.29	1.32	1.44	0.15	1.33	0.46	0.23
5	1.82	1.86	1.87	0.05	2.06	2.10	2.16	0.04	1.85	1.91	1.98	0.13	1.96	0.34	0.20
6	3.38	3.45	3.46	0.08	3.23	3.32	3.41	0.18	3.37	3.42	3.47	0.10	3.39	0.24	0.16
7	9.8	9.9	10.0	0.20	9.5	9.8	9.9	0.40	9.6	9.7	10.0	0.40	9.80	0.90	0.56
8	18.3	18.5	18.7	0.40	18.2	18.7	18.7	0.50	18.3	18.8	18.9	0.50	18.56	0.50	0.30
9	19.8	19.9	20.8	1.0	19.4	19.7	19.9	0.40	19.9	20.1	20.1	0.20	19.94	1.40	0.86
10	30.0	30.2	30.5	0.50	29.2	29.8	30.1	0.90	30.0	30.1	30.3	0.30	30.00	1.20	0.80

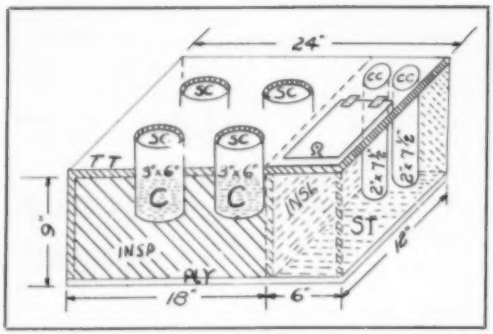


Figure 2 (above). Dry ice bath. (SC—Sample Chamber. CC—Cooling chamber 2" x 7½' stainless steel. ST—Storage compartment for dry ice. TT—Transite top surface. C—Kerosine/dry ice coolant. INSP—Insulated pack. INSL—Insulated lining. PLY—5-8" plywood).

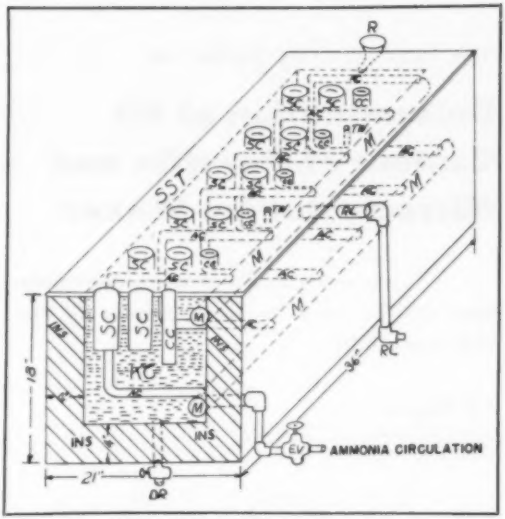


Figure 3 (right). Cooling Bath. (R—Refill Cap. SST—Stainless Steel Top 21" x 36". SC—Sample Chamber 2½" x 6" Stainless Steel. AC—Ammonia Coils. M—Manifold. CC—Cooling Chamber 2½" x 7½" Stainless Steel. INS—4" Insulation. KC—Kerosine Coolant. EV—Expansion Valve. RL—Return Line. DR—Drain. TW—Thermometer Well).

Insulated cooling bath capable of accommodating the desired number of cooling flasks and pre-cooling chambers. A small bath may be refrigerated with naphtha and solid carbon dioxide mixture. A large bath might be equipped with ammonia coils which are preferable. The temperature is maintained at —40 to —45 F. throughout the test.

Hot plate designed to operate at 160 to 180 F. for melting the wax samples and dissolving the wax in the solvent.

Solvent evaporating cabinet operating at 100 to 125 F. and equipped with air jets capable of delivering clean, dry air at controlled pressure. The air is blown vertically downward into the evaporating flasks. The temperature in the cabinet is thermostatically controlled.

Torsion or any laboratory balance capable of weighing to 0.1 gram.

Analytical balance capable of weighing to 0.1 mg.

Thermometers of —70 to +70 F. range to measure temperatures of the cooling bath and the cooling flasks.

Methylethyl ketone used as solvent should conform to ASTM specifications. The refractive index is maintained at 1.378 ± 002 at 68 F. and the residue left on evaporation of 100 ml is kept below 0.002 mgm.

Procedures for estimating the oil content of paraffin and microcrystalline waxes differ only in one minor degree as shown below.

A representative sample of wax is melted in a suitable container on the hot plate avoiding overheating. A 10 ± 0.1 gram sample of the melted wax is weighed out into the tared, sample flask on the torsion balance. To this is added 120 ± 0.1 grams of methylethyl ketone. The mixture is heated on the hot plate until the wax is dissolved and then placed quickly in the —40 F. bath. If a solid carbon dioxide-naphtha mixture is used in a small bath for refrigeration, the mixture is first placed in an intermediate ice bath before immersion into the —40 F. bath. In order to prevent formation of lumps, the contents are stirred intermittently until a temperature of —20 F. is reached and then stirred continuously until the temperature drops to —25 F.

TABLE 2
Extraction of Microcrystalline Waxes With Ethylene Dichloride

	PROPOSED								D721-51T Referee							
	Operator A			Repeatability	Operator B			Repeatability	Operator C			Repeatability	General Average	Total Deviations (Repeatability)	Average Deviations (Reproducibility)
	1	2	3		1	2	3		1	2	3				
1.	1.75	1.80	1.85	0.10	1.86	1.88	1.91	0.05	1.63	1.74	1.85	0.22	1.81	0.28	0.18
2.	2.08	2.10	2.13	0.07	2.14	2.32	2.44	0.30	1.94	2.11	2.26	0.32	2.17	0.38	0.27
3.	2.55	2.61	2.67	0.12	2.45	2.53	2.62	0.17	2.29	2.35	2.85	0.56	2.55	0.56	0.30
4.	3.69	4.10	4.31	0.82	3.56	3.74	3.87	0.31	3.96	4.11	4.35	0.42	3.99	0.95	0.52

TABLE 3
Extraction of Microcrystalline Wax by the Proposed and Ethylene Dichloride Methods

	ETHYLENE DICHLORIDE						METHYLETHYL KETONE					
	1	2	3	Average	Total Deviations	Average Deviations	1	2	3	Average	Total Deviations	Average Deviations
1.	1.31	1.38	1.42	1.37	0.11	0.06	0.62	0.65	0.73	0.67	0.11	0.06
2.	1.83	1.97	2.11	1.97	0.28	0.14	0.92	1.10	1.17	1.06	0.25	0.14
3.	3.03	3.07	3.08	3.06	0.06	0.03	1.63	1.73	1.86	1.74	0.22	0.11
4.	4.25	4.32	4.41	4.33	0.17	0.09	3.43	3.52	3.61	3.52	0.18	0.09
5.	5.24	5.32	5.40	5.29	0.16	0.11	3.97	4.09	4.25	4.10	0.28	0.15
6.	6.23	6.38	6.53	6.38	0.30	0.15	4.77	5.11	5.44	5.11	0.67	0.34
7.	11.0	11.3	11.8	11.37	0.80	0.43	6.82	7.23	7.63	7.23	0.81	0.41
8.	15.3	15.7	16.1	15.70	0.80	0.40	9.86	9.98	10.4	10.10	0.54	0.30
9.	16.4	16.8	17.2	16.80	0.80	0.40	10.3	10.6	10.8	10.57	0.50	0.27
10.	21.8	22.2	22.6	22.20	0.80	0.40	12.8	13.2	13.7	13.23	0.90	0.47

The pre-cooled filter stick is immersed quickly into the chilled mixture. The nozzle is attached to the receiving flask which has been tared to the nearest 0.1 mg and to a suction line on which a partial vacuum of 10 to 15 inches of mercury gauge is maintained. After 35 to 50 ml of filtrate have been collected in the flask, the flask is disconnected from the filter unit and weighed to the nearest 0.1 gram on the torsion balance to obtain the weight of the filtrate.

The flask is placed in the evaporation cabinet and the solvent is evaporated from the filtrate by using an air jet at 100 to 125 F. until the ketone odor disappears. The flask containing the oil residue is cooled to room temperature and weighed on the analytical balance to the nearest 0.1 mg to obtain the weight of the oil. The time required for the evaporation should be between 30 and 40 minutes. Special care should be taken to keep the equipment clean especially the filter assembly. Cleaning is done with ketone followed by air drying. The weight of the receiving flask should be checked regularly.

The oil content of the wax sample is calculated by means of the following equation:

$$\text{Oil, \% By Weight} = \frac{\text{Weight of Solvent}}{\text{Weight of Wax}} \times \frac{\text{Weight of Oil} \times 100}{\text{Weight of Filtrate-Wt. of Oil}} - 0.15$$

The procedure used for microcrystalline waxes differs from the procedure developed for paraffin waxes only in that the 0.15 factor is not employed in calculating the analytical results. The use of the correction factor is questionable because microcrystalline waxes in general have melting points outside of the 115 to 145 F. range from which this correction was developed.[1]

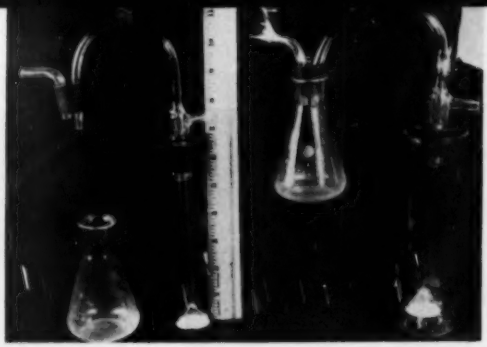


Figure 5. General view of filtration assembly for determining oil in microcrystalline and paraffin waxes by the proposed method.

The recommended procedure was developed from the results obtained on samples of paraffin wax ranging from less than 0.2 to 30 percent oil content. The samples were analyzed in triplicate by two operators. These samples were also analyzed in triplicate by a third operator by means of the semi-micro technique.[2] The average results and the deviations therefrom are shown in Table 1. The data show that with respect to paraffin waxes, the recommended procedure is as reliable as the Tentative Method of Test ASTM D721-51T[2] and compares favorably with ASTM requirements of repeatability and reproducibility.

The same procedure was used for determining the applicability of the method to microcrystalline waxes. The results were compared with those obtained by the ethylene dichloride method.[2] The oil content of the microcrystalline waxes varied from approximately 1.5 to 22 percent. The results are shown in Table 3.

The effect of employing ethylene dichloride instead of methylethyl ketone in the proposed procedure is shown in Table 2.

The data show that oil contents of microcrystalline waxes and petrolatum obtained by extraction with methylethyl ketone are very reproducible though consistently lower than those obtained by the ethylene dichloride method.[2] However, no information is available which would require the necessity of favoring one solvent over the other.

Heavy oils such as are associated with the microcrystalline waxes may have a tendency to separate from the methylethyl ketone but no indication of phase separation has been noted where the oil content of samples does not exceed 15 percent. Very high melting point microcrystalline waxes form cloudy solutions caused by the presence of small particles of undissolved wax; however, continuous stirring disperses the wax particles throughout the solvent and eliminates the undesirable effects of oil separation.

Conclusion

A single determination by the proposed method can be made in less than one hour. Additional and even more significant time saving is in the number of samples that can be run concurrently. As many as twenty or more determinations can be made by one operator in an eight hour shift. Samples run concurrently in groups of six are analyzed at an average rate of twenty minutes per sample. The method is well adapted for unit control operations and compares favorably with the ASTM requirements of repeatability and reproducibility.

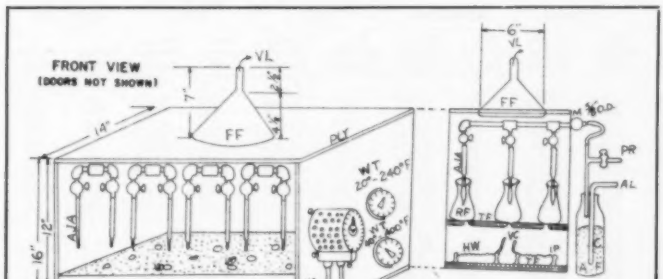


Figure 4. Evaporator. (AL—Airline. AF—Air filter. C—Cotton filter. TF—Transite floor. WT—Weston thermometer, upper and lower. PR—Pressure regulator. M—Manifold 5-8 inches o.d. FF—Fume funnel. RF—Receiving flask. VL—Vacuum line. AJA—Airjet assembly. HW—Heater wire. HC—Heater connection. VO—Ventilation openings. VC—Variac connection. V—Variac. IP—Insulated posts. PLY—¾-inch plywood).

ACKNOWLEDGMENT

Thanks are expressed to John H. Jordan of the Analytical Laboratory for his contribution in building the necessary glass equipment and to all those whose advice and cooperation aided materially in the development of this method.

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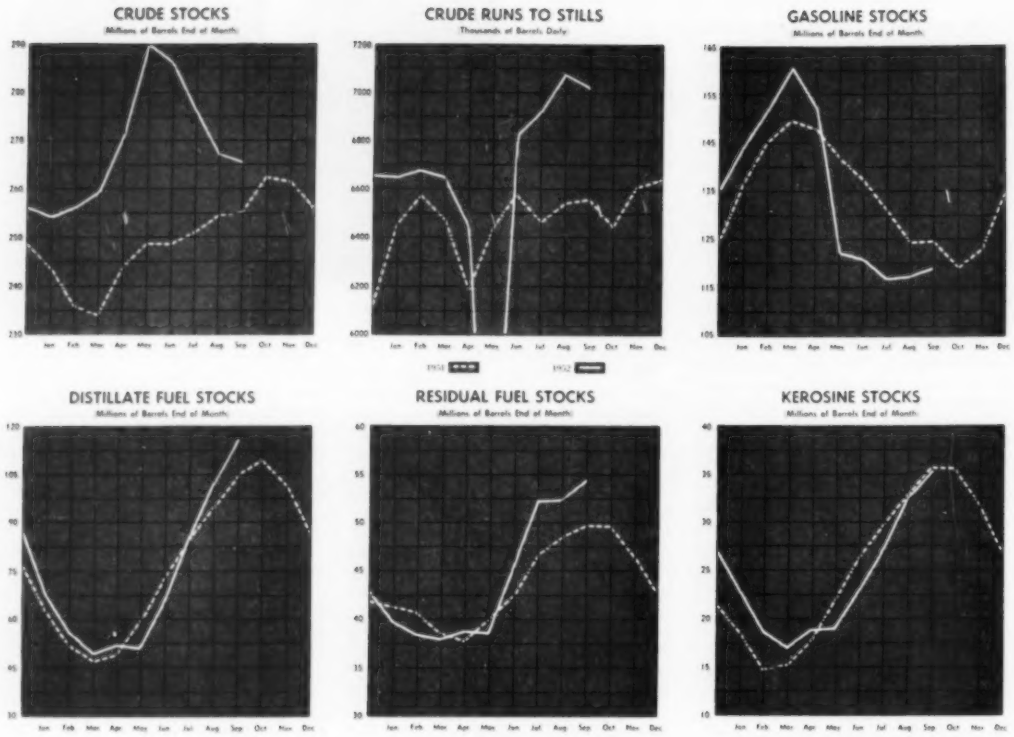
CRUDE STOCKS
Millions of Barrels End of Month
CRUDE RUNS TO STILLS
Thousands of Barrels Daily
GASOLINE STOCKS
Millions of Barrels End of Month
DISTILLATE FUEL STOCKS
Millions of Barrels End of Month
RESIDUAL FUEL STOCKS
Millions of Barrels End of Month
KEROSINE STOCKS
Millions of Barrels End of Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1951
1952

Taking Stock

Cecil W. Smith
Economics Editor

(DATA IN THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Daily	Production Month	Stocks End of Month	Production Daily	Stocks duction Month	Crude Oil	Total Oils
1951:													
March	6,052	6,469	233,824	2,908	149,679	399	15,135	1,327	46,744	1,348	38,366	483	861
April	6,127	6,183	243,180	2,821	147,679	384	17,639	1,171	48,239	1,230	37,623	511	871
May	6,170	6,436	248,418	3,031	141,658	345	21,974	1,210	59,272	1,265	39,879	518	876
June	6,130	6,575	248,170	3,100	137,009	317	26,204	1,254	72,140	1,277	42,398	563	876
July	6,141	6,462	250,847	3,091	130,931	341	29,679	1,228	84,282	1,275	46,320	546	788
August	6,232	6,539	254,276	3,114	124,202	339	32,728	1,237	94,028	1,226	48,365	529	780
September	6,261	6,558	254,900	3,127	124,530	364	35,773	1,282	104,082	1,228	49,608	500	744
October	6,375	6,446	262,266	3,105	118,864	363	33,759	1,295	108,544	1,224	49,573	421	769
November	6,272	6,609	261,100	3,130	122,723	403	32,116	1,358	101,666	1,304	46,491	425	802
December	6,182	6,646	255,783	3,150	134,867	393	27,088	1,442	86,619	1,313	42,853	423	834
1952:													
January	6,217	6,640	254,007	3,094	144,339	421	22,679	1,456	66,969	1,338	39,523	488	951
February	6,367	6,673	255,900	3,109	151,912	370	18,530	1,528	55,369	1,322	38,295	491	940
March	6,388	6,640	259,126	3,069	160,689	386	16,817	1,400	48,750	1,274	37,971	510	947
April	6,429	6,435	270,679	2,995	151,890	366	18,955	1,312	51,634	1,253	38,561	539	922
May	5,107	4,905	290,813	2,295	123,656	229	19,614	982	51,648	979	38,821	545	951
June	6,197	6,825	285,964	3,169	120,166	317	23,061	1,455	65,911	1,228	45,688	581	911
July	6,093	6,927	275,951	3,295	116,566	358	27,387	1,475	85,775	1,237	52,245	597	892
August	6,219	7,118	264,368	3,377	118,592	375	32,401	1,514	104,257	1,252	54,061	632	879
September	6,486	7,018	265,152	3,388	120,069	374	35,024	1,481	116,163	1,243	54,597	635	933
Sept., 1952—Change:													
In Month	+267	—100	+784	+11	+1,477	—1	+2,623	—33	+11,906	—9	+536	+3	+54
In Year	+225	+460	+10,252	+261	—4,461	+10	—749	+199	+12,081	—15	+4,989	+135	+189
Week Ended:													
10–18–52	6,528	6,898	266,466	3,307	122,002	371	34,568	1,455	121,143	1,202	54,450	762	1,095
10–20–51	6,353	6,481	258,208	3,120	121,450	345	35,767	1,352	108,593	1,215	50,537	335	588

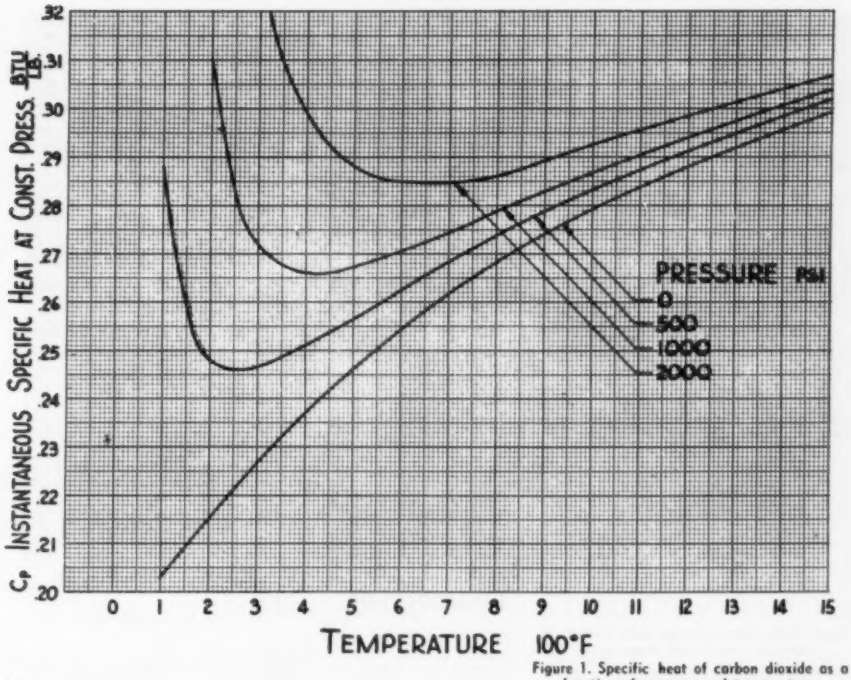

Figure 1. Specific heat of carbon dioxide as a function of pressure and temperature.

The Viscosity, Thermal Conductivity And Specific Heat of Carbon Dioxide at Elevated Pressures and Temperatures

Irving Granet and Philip Kass
Foster Wheeler Corporation
New York

THE ZERO pressure instantaneous specific heat of carbon dioxide can be obtained from various sources[1, 20, 4, 6, 7, 8, 11] and these references are generally in excellent agreement. For the high pressure range, the very comprehensive work of Sweigert et al.,[8] or the curves of the Cornell University investigators,[6] are available. However, Gratch[14] has indicated that the Sweigert values are probably in error. In view of this, the writers used the Cornell data. Figure 1 is a plot of the instantaneous specific heat of carbon dioxide as a function of pressure and temperature. Since the critical temperature of this gas is 88 F. and the critical pressure 1071 psia[6] it would be expected that at comparatively low temperatures (around 100 F.) there would be a very marked dependence of the specific heat, viscosity and thermal conductivity on pressure. In the case of the specific heat this is vividly shown in Figure 1. At higher temperatures the effect of pressure on the specific heat becomes less important, as would be expected.

Most of the published data on the viscosity and thermal conductivity of carbon dioxide are limited to low pressures. In a paper by Hawkins[12] some 133 references were examined and only one reference is given for viscosity and one for thermal conductivity of carbon dioxide. Keyes, in a series of papers,[9, 10] gives equations for these properties but the limited range of the data used to evaluate the constants in the equations may lead to serious error if these equations are extended beyond the experimental temperature and pressure limits.

Nuttall[28] has tabulated values for the viscosity of carbon dioxide over a very wide temperature range (2600 F.) and pressures up to 100 atmospheres. His values are taken from many sources, the principal ones being references.[5, 13] To the writers' knowledge this is the most complete tabulation available. Nuttall claims an accuracy of 2 percent for the viscosity, but the writers feel that this is probably of the order of 6 percent. In any case, the degree of accuracy is better than for most gases. The pressure values are in atmospheres to correspond to the tabulated values. The highest pressure given is 100 atmospheres and the writers felt it inadvisable to try to extend the range as such extrapolation might well lead to serious errors. The curve showing the viscosity of carbon dioxide as a function of pressure and temperature is given in Figure 2. For certain low temperature ranges not covered in this tabulation, the values were arrived at using the method and data of Uyehara and Watson.[15]

As previously noted, there is a scarcity of reliable thermal conductivity data for carbon dioxide. The papers by Keyes,[9, 10] Hawkins,[12] Tribus and Boelter,[7] Nuttall[28] and Gamson[5]

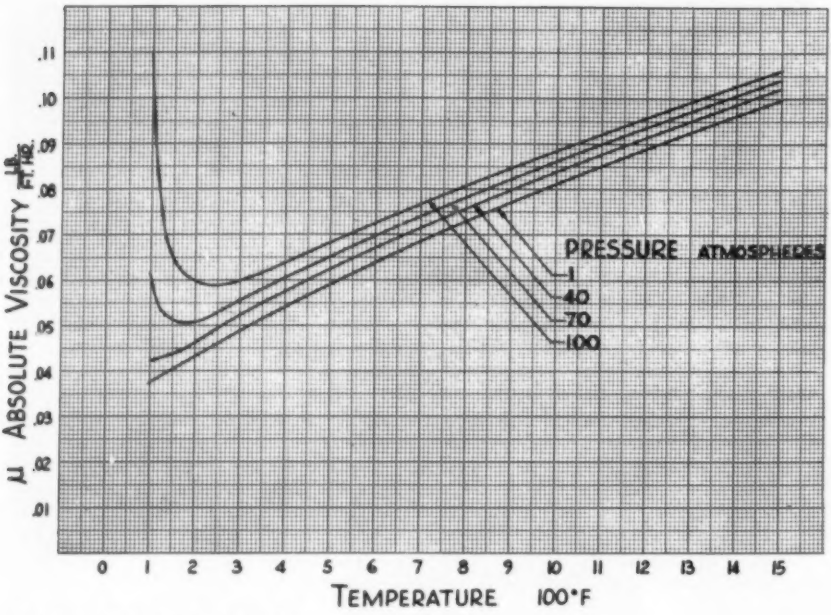

Figure 2. Viscosity of carbon dioxide as a function of pressure and temperature.

provide the major sources of data for this property. There is serious disagreement among the various investigators and after careful study, the writers feel that the method provided by Gamson[5] in conjunction with critical properties evaluated from the weighted low pressure data of the other investigators yields values which are reliable for engineering calculations. In general, this method has been found to yield results with an accuracy in the order of 5-8 percent. In view of this, Figure 3 showing the thermal conductivity of carbon dioxide as a function of pressure and temperature was developed using the Gamson[5] method.

This is the second of a series of articles on the high temperature-high pressure properties of gases. The first article on these properties of air appeared in the PETROLEUM REFINER *October, 1952.*

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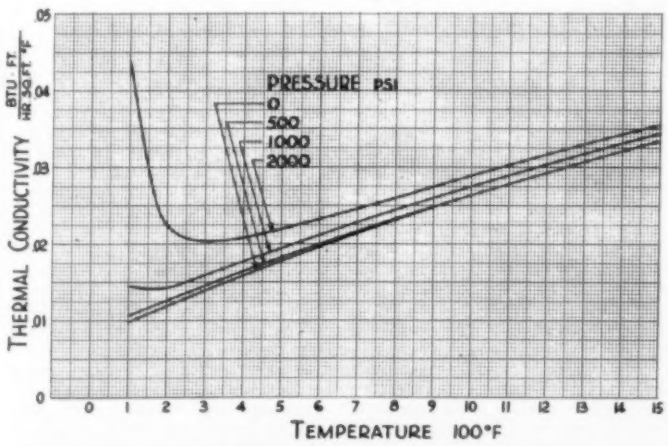

Figure 3. Thermal conductivity of carbon dioxide as a function of pressure and temperature.

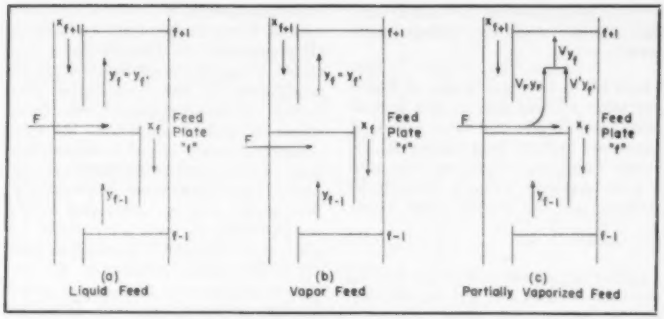

Figure 1. Feed plate location for various feeds.

Here's a way to make

Fractionation Calculations For Existing Columns

The methods of calculations are simple and systematic and have many applications to separation problems.

H. E. Rea, Jr., and D. N. Hanson,
University of California
Berkeley

RELATIVELY LITTLE attention has been given in the past to the important problem of determining what separation can be achieved on a particular feed by an existing column. Such calculations can be of great value in determining the necessary flow changes for a change in feed stock, or in determining the adaptability of a column to a new service. Furthermore, if the calculations are sufficiently rapid, such a method could be used to advantage as an original design method for establishing plates for separations for which other plate-to-plate calculations are difficult, in particular, in the design of a column for the separation of a system containing a large number of sandwich components.

Three basic methods for such calculations have been proposed in the literature, the first by Thiele and Geddes,[2] the second by Hummel,[2] and the third by Donnell and Turbin.[1] The three methods differ in many particulars, but all three require the initial assumption of the temperature gradient of the column. The majority of the work in these calculations is in the checking and correction of this gradient by trial and error. Also, two of these methods have failed to indicate how such calculations may be made so as to specify the distribution of one component in the system rather than the total amount of top product. Herein the methods of the above authors are integrated with additional techniques to give a method of calculation, which, the authors believe, is the most simple and straightforward method available at present.

Thiele-Geddes Method

With a given number of equilibrium steps and a reflux quantity, the Thiele-Geddes method is a rigorous plate-to-plate calculation in which the product compositions are computed by working with the mole fraction ratio of a component on a plate to the same component in the top or bottom product, i.e.,

$$(x_i)_n/(x_i)_d \text{ and } (x_i)_m/(x_i)_b.$$

This eliminates the necessity of knowing or assuming the overhead or bottom composition, but it requires the assumption of a temperature gradient for the column. These ratios are calculated from both ends of the column to the feed plate where they are matched to find the products. After matching, the calculated values of $(x_i)_d$ and $(x_i)_b$ for each component are used to obtain plate compositions. The temperature gradient is changed by trial and error, until, at the correct plate temperatures, $\Sigma(x_i)_d = 1$, $\Sigma(x_i)_b = 1$, and $\Sigma x_i = 1$ on each plate. Thiele and Geddes did not indicate a systematic procedure for correcting the temperature gradient that was assumed initially.

Hummel's method, like that of Thiele and Geddes, utilizes ratios from which product compositions may be calculated by matching at the feed plate. The method requires first being able to estimate the separation on all components. The feed plate temperature and composition must be estimated from infinite section calculations and depend on the estimated separation. A considerable amount of trial and error is required in shifting the temperature gradient and checking it.

Donnell and Turbin derived equations expressing component mole quantities as a function of the absorption and stripping factors. By equating the vapor component mole quantity of a given component from both sections at the feed plate, and using an over-all material balance, they obtained an expression for $(x_i)_d$. With an assumed temperature gradient for the column, these absorption and stripping factor functions are determined. Then the total moles of top product, d, is adjusted by trial and error until the values of $(x_i)_d$ calculated from the derived equation are such that $\Sigma(x_i)_d = 1$. With material balances and the absorption and stripping factor functions for this assumed temperature gradient, individual plate compositions are obtained. New plate temperatures are then obtained by running bubble points on each plate, that is, finding the temperature such that $\Sigma K_i x_i = 1$ for the calculated composition of each plate. With this new temperature gradient, the absorption and stripping factor functions are re-evaluated; the moles of top product again adjusted until $\Sigma(x_i)_d = 1$, etc., until the calculated plate compositions and the last assumed temperature gradient allow $\Sigma K_i x_i = 1$ and $\Sigma x_i = 1$ for each plate.

The authors believe that of these three methods, the Thiele-Geddes method is basically the simplest to use, provided that the proper techniques are used. Consequently, the equations of Thiele and Geddes have been employed here.

Equations

The use of mole fraction ratios permits Thiele and Geddes to work with a different set of variables than those of other design methods, and they avoid having to assume the distribution of all components in the system. The variables set in the Thiele-Geddes method are in general: 1) the number of rectifying plates, 2) the number of stripping plates, 3) reflux or some other flow, and 4) one separation variable. Of these variables, the first two

are fixed by the existing column. In the method as outlined by Thiele and Geddes, the separation variable set was the total amount of top or bottom product for a given amount of feed. Having set this bulk split, the distribution of all components could be calculated.

The basic equations that follow are those of Thiele and Geddes and are presented here primarily for the purpose of review. The plates in the column will be numbered from the bottom up, i.e., the bottom plate is plate number *l*, *m* is any plate in the stripping section, *n* is any plate in the rectifying section, and *t* is the top plate.

If a total condenser is used, then for any and each component.

$$y_t = x_d \qquad (1)$$

where y_t is the mole fraction of the component in the vapor leaving the top plate, and x_d is the mole fraction of the component in the liquid product. Equilibrium between the vapor leaving the top plate and the liquid leaving the top plate is given by:

$$y_t = K_t x_t \qquad (2)$$

Combining Equations (1) and (2):

$$x_t = \frac{y_t}{K_t} = \frac{x_d}{K_t}$$

or:

$$\frac{x_t}{x_d} = \frac{1}{K_t} \qquad (3)$$

A component material balance around the condenser and the top plate gives:

$$V_{t-1}y_{t-1} = L_t x_t + d x_d$$

or:

$$\frac{y_{t-1}}{x_d} = \frac{L_t}{V_{t-1}}\frac{x_t}{x_d} + \frac{d}{V_{t-1}} \qquad (4)$$

where V_{t-1} is the total moles of vapor per mole of feed entering the top plate from plate "t—1," L_t is the total moles of liquid per mole of feed leaving the top plate, and *d* is the total moles of top product per mole of feed. An over-all material balance around the top plate and condenser may be written:

$$\frac{d}{V_{t-1}} = 1 - \frac{L_t}{V_{t-1}} \qquad (5)$$

Combining Equations (4) and (5):

$$\frac{y_{t-1}}{x_d} = \frac{L_t}{V_{t-1}}\left[\frac{x_t}{x_d} - 1\right] + 1 \qquad (6)$$

Then, by equilibrium:

$$\frac{x_{t-1}}{x_d} = \frac{1}{K_{t-1}}\frac{y_{t-1}}{x_d} \qquad (7)$$

And by material balance:

$$\frac{y_{t-2}}{x_d} = \frac{L_{t-1}}{V_{t-1}}\left[\frac{x_{t-1}}{x_d} - 1\right] + 1 \qquad (8)$$

etc., down to the vapor entering the plate above the feed plate, if the temperatures on all plates and the phase ratios, L/V, have been assumed.

The stripping section equations are developed in a similar manner to those in the rectifying section. The vapor leaving the reboiler may be calculated by the equilibrium expression:

$$y_B = K_B x_b$$

or:

$$\frac{y_B}{x_b} = K_B \qquad (9)$$

A component material balance around the reboiler and the bottom plate gives:

$$L_1' x_1 = V_B' y_B + b x_b \qquad (10)$$

where L_1' is the total moles of liquid per mole of feed leaving the bottom plate, and V_B' is the total moles of vapor per mole of feed leaving the reboiler. Combining Equation (10) with a total material balance around the reboiler and the bottom plate gives:

$$\frac{x_1}{x_b} = \frac{V_B'}{L_1'}\left[\frac{y_B}{x_b} - 1\right] + 1 \qquad (11)$$

Equilibrium between the vapor leaving the bottom plate and the liquid leaving the bottom plate gives:

$$\frac{y_1}{x_b} = K_1\frac{x_1}{x_b} \qquad (12)$$

Then, by material balance:

$$\frac{x_2}{x_b} = \frac{V_1'}{L_2'}\left[\frac{y_1}{x_b} - 1\right] + 1 \qquad (13)$$

And by equilibrium:

$$\frac{y_2}{x_b} = K_2\frac{x_2}{x_b} \qquad (14)$$

etc., up through the feed plate to the vapor leaving the feed plate, again if the temperature and the phase ratios, V'/L', have been assumed.

The last ratios calculated are thus: $\frac{(y_1)_f}{(x_1)_d}$ obtained by calculating down from the top and $\frac{(y_1)_f'}{(x_1)_b}$ obtained by calculating up from the bottom. $(y_1)_f$ is the mole fraction of a component in the vapor entering the plate above the feed plate, and $(y_1)_f'$ is the mole fraction of the component in the vapor leaving the feed plate in equilibrium with the liquid leaving the feed plate. In order to compute the individual plate compositions, it is necessary to match the above ratios at the feed plate so as to obtain values of $(x_1)_d$ and $(x_1)_b$. This match must be made by different equations for different feed qualities. For illustration, consider saturated liquid feed. As will be shown later, in this case $y_f = y_f'$ and the ratio,

$$\frac{x_b}{x_d} = \frac{(y_f/x_d)}{(y_f'/x_b)} \qquad (15)$$

may be calculated for each component. From the over-all component material balance equation,

$$x_d = \frac{Fx_F}{b\dfrac{x_b}{x_d} + d} \qquad (16)$$

values of x_d may be obtained for individual components, and from the ratio $\frac{x_b}{x_d}$, values of x_b.

These values of x_d and x_b may then be used to calculate mole fractions of the components in the liquid on the plates of the column, since values of $\frac{x_n}{x_d}$ and $\frac{x_m}{x_b}$ have been calculated. If $\Sigma x_b = 1$, $\Sigma x_d = 1$, and $\Sigma x = 1$ on each plate, as stated previously, the assumed temperatures on the plates were correct. If any temperature was wrong, all plate totals are affected and a corrected temperature gradient must be established. It has been found that bubble points calculated on these values of plate composition, the temperature at which $\Sigma K_i x_i = \Sigma x_i$ on each plate, give excellent estimates of the correct temperatures. Alternatively, dew points run on calculated vapor compositions on each plate could be used, and reasoning indicates that bubble points might be better in the rectifying section and dew points better in the stripping section. However, little difference has been found in the correctness of the predicted gradient using either bubble or dew points, and for the sake of simplicity, it is suggested that bubble points be used throughout the column. Evaluation of each plate temperature is not necessary; only a sufficient number must be evaluated to establish the corrected gradient.

With the corrected temperature gradient, the calculation is repeated and the plate totals for this corrected gradient are obtained. A third temperature gradient is then obtained from these plate totals, etc., until it is apparent that the desired accuracy has been reached in the calculations. If desired, corrections to the equilibrium constants for non-ideality of solution can also be calculated from the estimated plate compositions and used for further accuracy. There are several indications of the accuracy of the calculations: 1) the degree to which the plate totals and Σx_b and Σx_d are approaching unity, 2) the change of the temperature gradient from one trial to another, and 3) the change in amounts of the individual components in one or the other of the products from one trial to another. Unfortunately, no rules exist for stating when the desired accuracy has been reached; however, a small amount of experience in this type of calculation will enable the calculator to judge when his particular requirements have been met, and in general the number of trials necessary is small. Example 1 shows a calculation of this type and shows the extreme rapidity with which the temperature gradient comes to the correct values even when the initially assumed gradient is quite wrong.

Feed Quality

In the outline presented thus far the feed has been considered saturated liquid, for which the matching at the feed plate is quite simple. However, feed plate matching must be considered for all three basic types of feed: namely, subcooled and saturated liquid, superheated and saturated

Example 1

	Feed	Specifications
C_3H_8	0.25 mole	Pressure = 150 psia
C_4H_{10}	0.25 mole	Reflux = 1 mole/mole of feed
C_5H_{12}	0.25 mole	Top product = 0.5 mole/mole of feed
C_6H_{14}	0.25 mole	Feed = Saturated liquid
		Plates = 7
		Feed Plate = Plate 4 (numbering from bottom)

The temperature gradient was first assumed to be a simple linear gradient between the boiling points of C_4H_{10} and C_5H_{12} (see Figure 2). Thiele-Geddes calculations were made with this gradient to obtain the mole fraction of each component in the liquid on the individual plates.

First Trial

	Tempera-ture °F.	MOLE FRACTION IN LIQUID, X				Plate Total ΣX
		C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	
Reboiler	260	0.001	0.052	0.432	0.497	0.982
Plate 1	249	0.004	0.091	0.437	0.323	0.855
Plate 2	238	0.011	0.140	0.411	0.239	0.801
Plate 3	227	0.029	0.193	0.365	0.200	0.787
Plate 4	216	0.072	0.241	0.314	0.180	0.807
Plate 5	205	0.083	0.298	0.284	0.087	0.752
Plate 6	194	0.111	0.362	0.223	0.036	0.732
Plate 7	183	0.200	0.420	0.144	0.012	0.776
Top Product	....	0.499	0.448	0.068	0.003	1.018

From the plate total calculated in the first trial, it is apparent that the temperatures are not very close to the correct values. From the temperature on each plate at which $\Sigma Kx = \Sigma x$, a second gradient is estimated (see Figure 2) and the calculations repeated.

Second Trial

	Tempera-ture °F.	MOLE FRACTION IN LIQUID, X				Plate Total ΣX
		C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	
Reboiler	282.5	0.001	0.049	0.451	0.499	1.000
Plate 1	265.8	0.003	0.097	0.527	0.372	0.999
Plate 2	250.0	0.011	0.164	0.535	0.282	0.992
Plate 3	232.7	0.030	0.243	0.487	0.227	0.987
Plate 4	211.3	0.077	0.313	0.403	0.192	0.985
Plate 5	194.2	0.096	0.425	0.365	0.089	0.975
Plate 6	176.5	0.140	0.533	0.268	0.032	0.973
Plate 7	152.9	0.250	0.576	0.151	0.009	0.986
Top Product	....	0.499	0.451	0.049	0.001	1.000

For all practical purposes the second trial is sufficiently correct. However, a third trial was run to illustrate what further change can be expected.

Third Trial

	Tempera-ture °F.	MOLE FRACTION IN LIQUID, X				Plate Total ΣX
		C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	
Reboiler	282.4	0.001	0.050	0.452	0.498	1.001
Plate 1	266.3	0.003	0.098	0.529	0.372	1.002
Plate 2	250.9	0.011	0.166	0.542	0.282	1.001
Plate 3	233.0	0.030	0.248	0.497	0.227	1.002
Plate 4	211.2	0.077	0.319	0.411	0.193	1.000
Plate 5	193.3	0.098	0.439	0.372	0.089	0.998
Plate 6	174.5	0.143	0.549	0.272	0.032	0.996
Plate 7	151.3	0.253	0.585	0.150	0.008	0.996
Top Product	....	0.499	0.450	0.048	0.001	0.998

vapor, and partially vaporized feed. These three types of feed are shown schematically in Figures 1-a, 1-b, and 1-c. The point of entry of the feed is also shown.

Considering first the case of saturated liquid feed (Figure 1-a), the usual assumption made in distillation calculations is that the feed plate is the plate below the point of feed entry, and that the liquid leaving the feed plate is in equilibrium with the vapor leaving the feed plate. This vapor is thus fixed in composition regardless of the composition of the feed if calculations are made up the column to the feed plate. Similarly, the vapor leaving the feed plate is in material balance with the liquid leaving the plate above the feed plate, plate "f+1," and again the vapor composition is fixed regardless of feed composition if calculations are made down the column to the feed plate. In the Thiele-Geddes calculations $\frac{y_f}{x_d}$ is obtained calculating down the column and $\frac{y_f'}{x_b}$ calculating up. Since the feed has no effect on y_f or y_f', then $y_f = y_f'$, and these vapors may be used for matching at the feed plate. The same reasoning holds for sub-cooled liquid feeds.

In the case of saturated vapor or superheated vapor feeds, the reasoning again holds if the feed plate is the plate *above* the point of entry of the feed (Figure 1-b), and the feed plate match may again be made on y_f and y_f' since these are again equal.

For partly vaporized feeds, the calculation is more complex. Here three conditions of feed entry are possible. If the feed is separated before entering the column, the liquid introduced above the feed plate and the vapor below the feed plate, then again $y_f = y_f'$, and the match is made in the normal fashion. However, the common method introduction of partially vaporized feed would be as illustrated in Figure 1-c, where the liquid and vapor were both introduced above the feed plate. Under these conditions, y_f' is in equilibrium with x_f, but Vy_f is a mixture of $V_F y_F$, the vapor portion of the feed, and $V'y_f'$, the vapor in equilibrium with the liquid leaving the feed plate, namely,

$$Vy_f = V_F y_F + V'y_f' \qquad (17)$$

and $y_f = y_f'$. The Thiele-Geddes calculations give the ratios $\frac{y_f}{x_d}$ and $\frac{y_f'}{x_b}$, and a matching relation utilizing these ratios must be derived. Such a relation, replacing Equation (16) as the matching equation, is,

$$x_d = \frac{Fx_F + b\left[\dfrac{V_F y_F}{V'(y_f'/x_b)}\right]}{b\dfrac{V}{V'}\dfrac{(y_f/x_d)}{(y_f'/x_b)} + d} \qquad (18)$$

Values of x_b may be calculated using the values of x_d from Equation (18) from the over-all component material balance,

$$x_b = \frac{Fx_F - dx_d}{b} \qquad (19)$$

A third possibility of feed entry exists. The feed could be introduced in such a manner that the liquid portion was introduced almost directly into the downcomer leading from the feed plate, and the vapor was introduced above the feed plate. Essentially, this amounts to feeding the liquid on the next plate below the "feed" plate. Equations have not been developed for the match in such a case, and the match must be done by a tedious trial and error calculation around the feed plate.

In many cases, the exact location of the feed plate in influencing the separation is of secondary importance, and for convenience, in these cases, particularly those of high or low percent vaporization, Equation (16) could be used. Equation (18) offers the correct solution for the majority of cases, but it is more difficult to use.

Control Component Distribution

The calculations as outlined previously follow the original paper of Thiele and Geddes in that the variables set, in addition to rectifying plates and stripping plates, are a flow, generally reflux, and the total amount of either top or bottom product.

A much more useful stipulation, in general, is the amount of one component in one of the products, or a "control component" distribution. Then, having set the reflux and the distribution of the control component, the distribution of all other components can be calculated. Such a calculation would be of particular value in determining the change in fractionation which would be found with a change of feed stocks when the column loading is held approximately constant through holding the reflux.

The calculations for this case could be accomplished holding the variables stipulated by Thiele and Geddes. If an amount of total top product were set, the column could be calculated and the distribution of all components corresponding to this total top product found. If the distribution of the particular component of interest were not that desired, the calculations could be repeated with a second amount of total top product and a second distribution

found. It would only be necessary to calculate enough points so that curves could be drawn to ascertain at what total top product the correct distribution of the control component would be obtained, and also what the corresponding distributions of the other components were.

A procedure, and one which the authors propose, is to hold the distribution of the control component at the desired value throughout the calculations.

The number of moles in the top product, dx_d, or bottom product, bx_b, of the control component is thus set, and the total moles of top or bottom product which will give this distribution of the control component, for the particular reflux and the assumed temperature gradient, must be determined. To obtain this value of d or b requires a trial and error calculation based on the control component. A value of d is assumed, and calculations are made through the column on the control component only to obtain the ratios $\frac{y_f}{x_d}$ and $\frac{y_f'}{x_b}$ for this component. For the cases of liquid and vapor feeds, these ratios may be matched at the feed plate, since $y_f = y_f'$, to give the ratio $\frac{x_d}{x_b}$ for the control component. By rearranging an over-all material balance, an equation is obtained that is independent of d and b, and in which the ratio $\frac{x_d}{x_b}$ is used to calculate a new value of d.

$$d = \frac{F}{\frac{bx_b}{dx_d}\frac{x_d}{x_b} + 1} \qquad (20)$$

Another value of d is assumed; a new ratio of $\frac{x_d}{x_b}$ is calculated, and another value of d is calculated by Equation (20). This is repeated until the assumed value of d equals the calculated value of d. It was found that small differences in the assumed value of d would result in relatively large differences in the calculated value. For this reason, it is suggested that a crude graph be employed to ascertain the correct value of d. Once the correct value has been obtained, the total moles of bottom product, b, is easily obtained from an over-all material balance. These values then are the values of d and b which will give the correct separation on the control component for the assumed temperature gradient and the particular reflux.

Calculations are now made through the column with these values of d and b, carrying all components to obtain the respective values of the ratio $\frac{x_d}{x_b}$ for the other components. Matching at the feed plate using Equation (16) will give the distribution of the other components. Plate totals are calculated, and bubble points run on them to establish a corrected temperature gradient.

For the corrected temperature gradient, a new value of d must be calculated which will hold the control component distribution, and the calculations repeated until the desired accuracy is reached.

For partly vaporized feeds, Equation (20) is not correct, and new values of d may be calculated by:

$$d^2 \cdot \frac{V_F y_F}{dx_d \cdot V(y_f/x_d)} - d \left[1 + \frac{bx_b \cdot V'(y_f'/x_b) + F \cdot V_F y_F}{dx_d \cdot V(y_f/x_d)} \right] + F = 0 \qquad (21)$$

For reasons previously stated, Equation (20) could be used with little error for calculating new values of d rather than Equation (21) for those cases of high or low percent vaporization.

It should be apparent that holding the correct distribution for the control component essentially requires only the determination of the value of d (or b) which corresponds to the set distribution of this component for the temperature gradient being used and the value of the reflux. After this value of d has been established, the calculations follow exactly the same pattern of the calculations outlined in the first part of this paper and as outlined by Thiele and Geddes. This is true for any particular specification which is to be held. In order to perform plate-to-plate calculations of the Thiele-Geddes type, it is necessary to establish values of all flows in the column, which means that the reflux (or any other flow) must be known along with both the total top and bottom product. The setting of any variable such as the distribution of a particular component, which necessitates leaving one of the other variables such as d or the reflux unset, simply means that the column flows which correspond to this specification must be established. The calculations then always proceed in the same way to check the plate totals and to establish a corrected temperature gradient on which the entire calculation is repeated.

It should also be apparent that instead of setting the reflux along with the distribution of the control component, it is possible to set the amount of top and bottom products. This set of specifications is probably the most useful which can be made; the distribution of a particular component is held along with the amounts of top and bottom products, thus holding directly the recovery and purity of the control component. In many cases these specifications are also essentially equivalent to setting the recovery of two components, since if no components lie between the two components in volatility, it is possible to estimate with fair accuracy the distribution of all components, and thus estimate the d and b which will correspond to the two recoveries.

With the specification of the distribution of a control component and the amounts of top and bottom products, d and b, the calculations yield the distribution of all other components and the reflux requirement. They become very useful then for calculating the amount of feed which may be handled in an existing column for a particular separation. With these specifications set, the reflux quantity corresponding to the specifications and the temperature gradient being used must be calculated. Again, this requires trial and error calculations. A value for the reflux is assumed and calculations are made through the column for the control component only. A match is made at the feed plate using either Equation (20) or (21) and a value of d calculated. If this value does not check the value of d set in the specifications, other values of reflux must be selected and the calculation repeated until the correct value of reflux is obtained. As a guide in the choice of a new value of reflux, if the calculated value of d is less than the correct value, the reflux should be increased, and vice-versa. When the correct value of reflux has been determined, calculations are made through the column on all components, a match is made at the feed plate with Equation (16) or (18), the plate totals computed, and the temperature gradient corrected. The entire calculation is then repeated with the corrected temperature gradient.

Temperature Specification

The specification of the temperature on any plate, or, most often, in the reboiler is another type of calculation which is of interest. Calculations can be made with the Thiele-Geddes equations holding, for example, the temperature in the reboiler and either the total top or bottom product or the reflux.

If the reflux and the temperature of the reboiler are set, then the amount of bottom product (or top product) required to give this reboiler temperature must be evaluated by trial and error for the temperature gradient being used and for the particular reflux. A value of b is assumed in order to determine the flows in the column and thereby obtain values for L/V and V'/L', and calculations are made through the column on all components.

By matching at the feed plate with the analogue of Equation (16) or (18), values of x_b are obtained. These values of x_b correspond to the assumed temperature gradient and the value of b chosen. The next step in the calculation must then be to ascertain whether this indicated bottom product composition has the correct bubble temperature. The bubble point calculation is run using the equilibrium constants at the desired temperature. If ΣKx_b is greater than Σx_b, the bottom product is too light for the desired temperature and lower values of b must be tried until a value of b is found with which $\Sigma Kx_b = \Sigma x_b$. If ΣKx_b is less than Σx_b, then the value of b must be increased.

With the correct value of b, i.e., the value of b which will hold the desired reboiler temperature for the temperature gradient employed, calculations are made through the column on all components and plate totals computed so that a corrected temperature gradient may be established. With the corrected temperature gradient, a new value of b must again be determined which will hold the desired reboiler temperature. Plate totals are then computed, and the second corrected temperature gradient is obtained. These calculations are repeated until the desired accuracy has been reached.

Distributing Band

The mixture to be fractionated very often contains components widely different in volatility. Since the separation is generally fairly tight on a few components close to each other in volatility, the components which are relatively more volatile than these or less volatile go almost completely into one or the other of the products. When such a component does go completely into one of the products within the accuracy of the calculations, then there is no need to use Thiele-Geddes calculations on this component since its distribution is known. If, for example, the component goes "completely" into the bottom product, then by simple conventional plate-by-plate calculations from the bottom, its concentration on each plate can be determined. Similarly, if a component goes completely into the top product, then calculations from the top will give its concentration on the various plates.

In many cases most of the components present can be regarded as going completely into one of the products, or as non-distributing. The distributions of the remaining components, the distributing band of components, must still be calculated by the Thiele-Geddes calculations, but in general, the work is greatly reduced by the reduction in the number of these components. For example, in the calculations described in the last section, holding the temperature in the reboiler and the reflux, various values of b must be tried until a value is found such that $\Sigma Kx_b = \Sigma x_b$. For all light non-distributing components, $x_b = 0$. For all heavy non-distributing components, $x_b = \frac{Fx_F}{b}$. The values of x_b for the distributing band must be obtained by Thiele-Geddes calculations, but it is apparent that the work in evaluating the correct value of b is much less than it would be if the distribution of all components had to be calculated by the Thiele-Geddes method.

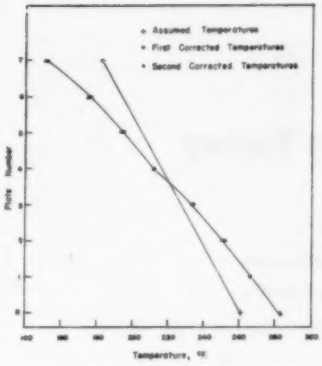

Figure 2. Initial assumed temperature gradient and corrected gradients for Example 1.

NOMENCLATURE

- b = total moles of bottom product, moles/mole of feed
- d = total moles of top product, moles/mole of feed
- F = moles of feed, equal to one for convenience
- K = equilibrium constant = y/x
- L = rectifying section liquid flow, moles/mole of feed
- L' = stripping section liquid flow, moles/mole of feed
- V = rectifying section vapor flow, moles/mole of feed
- V' = stripping section vapor flow, moles/mole of feed
- V_F = vapor portion of feed, moles/mole of feed
- x = mole fraction of a component in a liquid
- y = mole fraction of a component in a vapor

Subscripts

- b refers to bottom product
- d refers to top product
- f refers to the feed plate
- F refers to feed
- i refers to any general component
- m refers to any plate in the stripping section
- n refers to any plate in the rectifying section

No rule can be established to tell whether a component will lie in the distributing band or not. This will be a function of the volatilities, the tightness of the separation in the distributing band, and what components comprise this band. In general, in the first trials it is convenient to assume the smallest reasonable number of components in the distributing band, and to correct this later. Calculation through the column will indicate whether or not a component must be considered to be in this band in future trials.

Phase Ratio Gradient

Up to this point in the discussion the flows have been tacitly assumed to be constant throughout any column section. Thus L/V and V'/L' have been assumed not to vary. However, the correction of this assumption is quite easy. Heat balances between the plates can be run after the calculations are sufficiently well along that reasonable temperatures and plate compositions are known and corrected values of L/V and V'/L' established between the plates. Again it is not necessary to evaluate the phase ratio between each set of plates, but only enough points to enable drawing of the phase ratio gradient.

Because of the fact that the Thiele-Geddes calculations use phase ratios, the flows of the individual streams can often change considerably through a section of the column with relatively little corresponding change in the phase ratio, and the corrections for the change in flows are thus rapid. In general only a single correction of the phase ratio gradient is necessary.

Discussion

The various applications of the Thiele-Geddes method which have been discussed show the wide usefulness of the method. Since it is so uniquely adapted to use with existing columns, many of the fractionation problems associated with refinery operation can be readily solved with the method, and without excessive labor. Those acquainted with ordinary plate-by-plate distillation calculations are well aware of the tedious nature of such calculations, and will recognize that the methods proposed here are, for many problems, considerably easier to use. The authors feel that although the techniques elaborated here are relatively few, a sufficient number are presented that the method may be systematically and simply used.

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Storage Tank Evaporation Losses Today

- **Basic theory and mechanism**
- **Losses from cone-roof tanks**
- **Evaporation from conservation-type tanks**

THE SYMPOSIUM on Evaporation Loss of Petroleum from Storage Tanks, presented during the 32nd Annual Meeting of the American Petroleum Institute, pointed to the practical problem of this subject—an abundance of opinion in contrast to a marked scarcity of facts. The papers presented represent the views of three subcommittees, organized by API's Program Committee on Evaporation Loss Symposium.

I. A Review of the Basic Theory and Mechanism and an Outline of the Practical Problem

This paper, presented by the Group "A" Subcommittee as its contribution to the API evaporation-loss symposium, discusses the phenomenon of loss of petroleum liquids from steel tanks by the natural process commonly termed "evaporation"; reviews the basic theory and mechanism of that process, and outlines the scope of the practical problem encountered when an effort is made to translate theoretical considerations and observed experience into typical data of sufficient accuracy to permit valid evaluation of probable loss conditions for existing or new tankage. The general statements given are applicable in many cases to both crude oils and gasolines, but there is ample evidence that more data are needed before broad applications for crude oils can be made. A recommended terminology for evaporation-loss work is included, together with a classified bibliography of representative published data on the subject. Papers II and III, presented by Groups "B" and "C," respectively, offer evaluations of different phases of the problem.

II. Losses from Cone-Roof Tanks

This section of the symposium discusses evaporation losses from tanks which operate at essentially atmospheric pressure. They are called cone-roof tanks in the title because, in the larger sizes, tank roofs are usually of that form. This paper, however, is not limited to cone-roof tanks, but includes all fixed-roof tanks with vents which have very low settings.

Losses from cone-roof tanks, or from tanks which operate at essentially atmospheric pressure, are of first importance because this type of storage is the minimum accepted standard in present-day practice. Herein lies the entire justification for the additional first cost and maintenance of oil-conservation devices and systems. The monetary value of cone-roof tank losses justifies the work of many men in the petroleum and associated industries who are constantly endeavoring to develop the best conservation methods for the least outlay of capital investment and expense.

III. Evaporation from Conservation-Type Tanks—A Practical Review

In the storage of all volatile petroleum products the conservation-type tank is finding increasingly greater application. Primarily, the reason for this increased usage lies in the reduction of breathing and filling losses which are normally experienced in a cone- or fixed-roof tank. In addition, there are other less tangible operating advantages such as decreased fire hazards and, in the case of floating-roof tanks in sour-stock service, decreased rates of corrosion.

If, under stated conditions of operation, the losses from a conservation-type tank are known or can be predicted with reasonable accuracy, and if the losses from a cone-roof tank under similar conditions of operation are known in like manner, then it becomes possible to predict the annual saving resulting from the use of conservation tankage. This represents a primary factor in determining the payout. The evaluation of the payout would also require data on the cost of the tankage to be compared, on tax structures, and on company policies. All of these are matters to be determined by individual companies for particular situations. Particular decisions in favor of installing conservation equipment will, at times, be made on the basis of the less tangible operating advantages rather than the reduction of evaporation losses.

The data in this report and in the report submitted by Subcommittee "B" will serve, therefore, as a basis for computing the economic advantages of conservation-type tanks over cone- or fixed-roof tanks. Inasmuch as the various types of conservation tanks are listed, it is possible by means of an extension of these data to determine not only when a cone or fixed roof should *not* be used, but also specifically what type of conservation tank *should* be used.

In the case of the floating-roof tank climatic factors in connection with its use should be given consideration. For instance, extremely cold weather and heavy snow will cause operating problems. The pan roof is particularly critical in this regard, and it is recommended only for the storage of crude oils in the southern and southwestern parts of the country. Variable vapor-space tanks and low-pressure tanks are less affected by climatic conditions than are floating-roof tanks.

The floating-roof tank is used for all volatile products which will not boil at storage temperatures, and is the most important conservation tank used for the storage of crude oil, although the breather-roof tank finds infrequent application for this latter purpose. The variable vapor-space tank is used almost entirely for motor- and aviation-gasoline storage. The low-pressure tank is usually used for products with vapor pressures too high to be stored in the other types of conservation-type tanks.

It would be convenient and highly desirable if general rules could be established as a guide to indicate the proper use of cone-roof tanks, floating-roof tanks, low-pressure tanks, and variable vapor-space tanks. In this respect we have prepared such an approximate guide, but the data indicated may be misleading in any specific case because of the many variables which must be considered.

Complete copies of the three papers are available from American Petroleum Institute, 50 West 50th Street, New York 17.

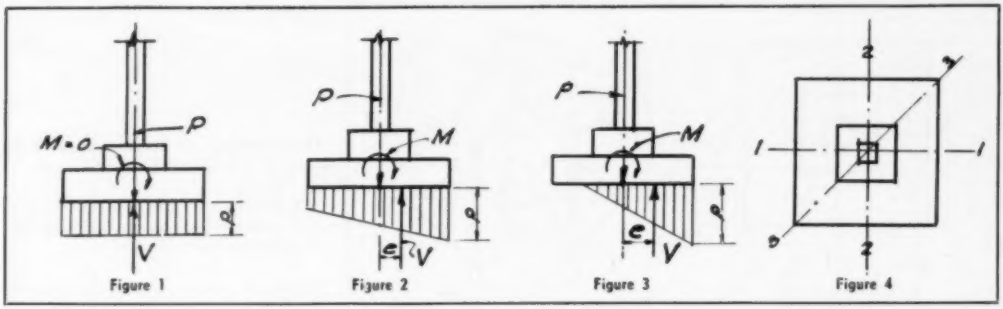

Figure 1 Figure 2 Figure 3 Figure 4

Applying Graphical Methods to SQUARE FOOTING DESIGNS

Much of the usual trial-and-error procedure in design of stack and tower foundations eliminated by this method

Charles H. Fork
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SQUARE FOOTINGS are found to have more general use in industrial and commercial projects than any other shaped footing. In refinery and chemical plants they are used to support tanks, equipment, etc. The author discussed circular and octagonal footings in a previous article.[1] This discussion on square footings is in effect a continuation of the same subject. This time we are applying the same principles to square footings.

The discussion is limited to determining the size of the footing when a direct load and moment are acting simultaneously on the footing. Such a condition arises in case of an earthquake or a wind storm.

Figures 1, 2, and 3 represent a footing with different load and moment combinations acting upon it. Figure 1 represents a footing under a direct load only, the moment being zero. Here the pressure diagram under the footing is uniform and its shape is a rectangle. In Figure 2 there is a direct load and a small moment acting on the footing. The pressure diagram then becomes trapezoidal in shape. In Figure 3 there is direct load and a large moment acting on the footing. The pressure diagram then becomes triangular in shape.

Figure 1 does not present any special problem and will not be discussed.

Figure 2 with a trapezoidal stress diagram will be discussed under Case I; while Figure 3 with a triangular pressure diagram will be discussed under Case II.

Nomenclature

P — Total load at base of footing.
M — Overturning moment at base of footing.
e — Eccentricity $\frac{M}{P}$
p — Maximum soil pressure.
k and m are fractions.
D — Dimension of footing.
V — Volume of earth pressure solid.
M_1 — Moment of earth pressure solid.
$\bar{x}$ — Distance to center of gravity of earth pressure solid.
C_1, C_2 and C_3 are coefficients.

Where the moment acts in any direction around the clock, it is necessary to investigate the overturning resistance for the critical cases. This can be accomplished by developing one set of equations for the rectangular or stronger axis 1-1 and 2-2 and another set for the diagonal or weaker axis 3-3. See Figure 4.

Equations (1) through (12) and Chart 1 are for overturning on rectangular axis. For the diagonal axis Equations (13) through (22) and Charts 3 and 4 are used. Four examples, illustrating the use of the equations and charts are given at the end of the article.

Cases I and II

Static equilibrium is obtained as follows: Refer to Figures 2 and 3.

(a) $\Sigma V = 0$. The volume of the pressure diagram must equal the weight of the structure above. That is: $V - P = 0$ or $V = P$.

(b) $\Sigma M = 0$. The external moment applied to a footing is resisted by the eccentric action of the pressure diagram on the footing. That is: $M - Ve = 0$ or $M = Ve$.

Again the principal problem is one of evaluating the pressure diagrams and presenting the data for convenient use for structural design. Cases I and II are now considered in detail.

Overturning on Rectangular Axis

Case I. Trapezoidal Earth Pressure Solid

Figure 2a illustrates a Case I problem: A footing with a direct load "P." A moment "M" is acting about the rectangular axis. Referring to Figure 2a, the volume and center of gravity of the trapezoid is as follows:

Load P = Volume V, also $e = \frac{M}{P}$

$$V = p\frac{D^2}{2}(m + 1) \qquad (1)$$

Center of gravity of trapezoid from

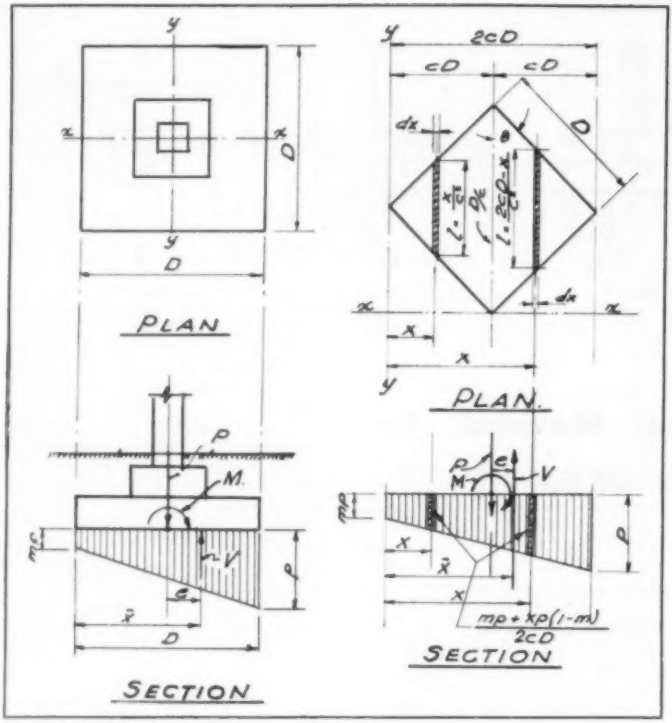


Figure 2a

Figure 2b

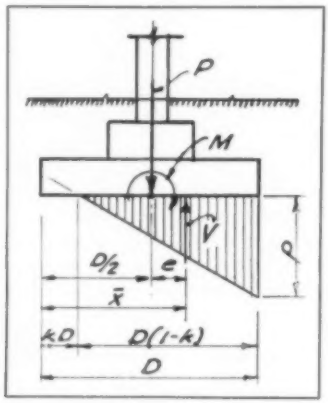


Figure 3a

Figure 2a $\bar{x} = \frac{D}{2} + e$ (2)

By taking moments about left side, $\bar{X}$ also is as follows: $\bar{x} = \frac{D}{3}\left(\frac{m+2}{m+1}\right)$ (3)

$\bar{x}$ can vary from $\frac{D}{2}$ minimum to $\frac{2}{3}D$ maximum.

To obtain a solution for e and D equate Equations (2) and (3).

$$\frac{D}{2} + e = \frac{D}{3}\cdot\frac{m+2}{m+1} \text{ then } e = \frac{D}{6}\cdot\frac{1-m}{1+m} \quad (4)$$

$$\text{and } D = 6e\,\frac{1+m}{1-m} \quad (5)$$

From Equation (1) D may also be obtained:

$$D = \sqrt{\frac{2V}{p(1+m)}} \quad (1a)$$

A relation between the known quantities, P, M, e, p and the unknown quantity m are obtained by equating (1a) and (5).

$$\sqrt{\frac{2V}{p(1+m)}} = 6e\,\frac{1+m}{1-m}$$

$$\text{then } \frac{V}{18e^3p} = \frac{(1+m)^3}{(1-m)^3} \quad (6)$$

If "a" represents each term, then $a = \frac{V}{18e^3p}$ also $a = \frac{(1+m)^3}{(1-m)^3}$

maximum value of $a = \infty$, minimum value = 1.0.

In Equation (6) the left term has all known quantities and are obtained by slide rule. This value is then used in Graph No. 1 to obtain "m." The reverse operation, if D is known—to find "m" and p.

Solving Equation (5) for "m",

$$m = \frac{D-6e}{D+6e} \quad (5a)$$

Solving Equation (1) for p,

$$p = \frac{2V}{D^2(m+1)} \quad (1a)$$

Overturning on Rectangular Axis

Case II. Triangular Earth Pressure Solid

Referring to Figure 3a, the volume and center of gravity of the triangle of pressure are as follows:

$$V = pD^2(1-k) \quad (7)$$

Center of gravity of triangular solid.

From Figure 3a; $\bar{x} = \frac{D}{2} + e$ (8)

Taking moments about left side, $\bar{x}$ is also equal to the following:

$$\bar{x} = \frac{D}{3}(k+2) \quad (9)$$

To obtain a solution for e and D equate (8) and (9).

$$\frac{D}{2} + e = \frac{D}{3}(k+2)$$

$$\text{Then } e = \frac{D}{6}(2k+1) \quad (10)$$

$$\text{and } D = \frac{6e}{2k+1} \quad (11)$$

From Equation (7) D also equals:

$$D = \sqrt{\frac{2V}{p(1-k)}} \quad (7a)$$

To obtain a relation between k and the known quantities M, P, e, p, equate (7a) and (11).

$$\sqrt{\frac{2V}{p(1-k)}} = \frac{6e}{2k+1}$$

$$\text{or } \frac{V}{18e^3p} = \frac{1-k}{(2k+1)^3} \quad (12)$$

If "a" is made to represent each term

$$\text{Then } a = \frac{V}{18e^3p} \text{ and } a = \frac{1-k}{(2k+1)^3}$$

Maximum value of a = 1.0; minimum value = 0.

In Equation (12) the left term has all known quantities and are obtained by slide rule. This value is then used in Graph 2 to obtain "k."

The reverse operation, if D is known, to find k and p:

Solving Equation (11) for k

$$k = \frac{1}{2}\left(\frac{6e}{D} - 1\right) \quad (11a)$$

Solving for Equation (7a) for p

$$p = \frac{2V}{D^2(1-k)} \quad (7b)$$

Overturning on Diagonal Axis

Case I. Trapezoidal Earth Pressure Solid

Volume of trapezoidal solid:

The length of the differential elements as a function of x are obtained by proportional triangles and are as indicated in Figure 2b.

Note $c = \cos\theta = .707$

$$V = \int_0^{cD} \frac{x}{c^2}\left(pm + p\,\frac{(1-m)x}{2cD}\right)dx +$$

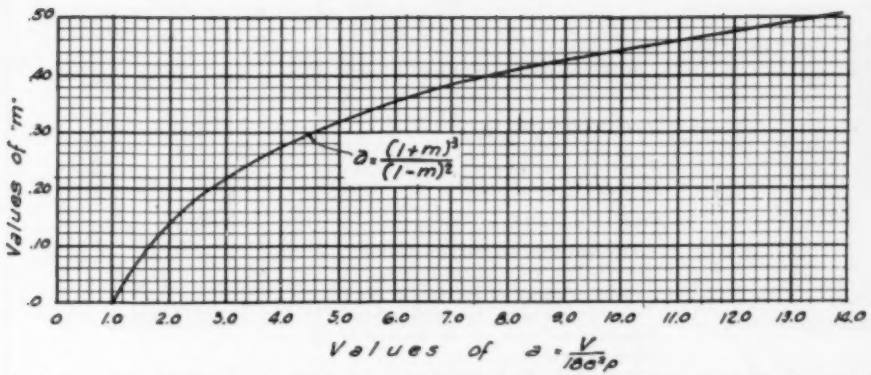


TABLE #1

m	a
0	1.0
.1	1.65
.2	2.70
.3	4.48
.4	7.65
.5	13.5
.6	25.6
.7	54.6
.8	145.8
.9	686.0
1.0	∞

Graph 1 for Case I problems. Overturning on rectangular axis. This graph applies where "a" is 1.0 or greater. For values of "m" greater than 0.50 use Table 1. To interpolate, use a straight-line variation.

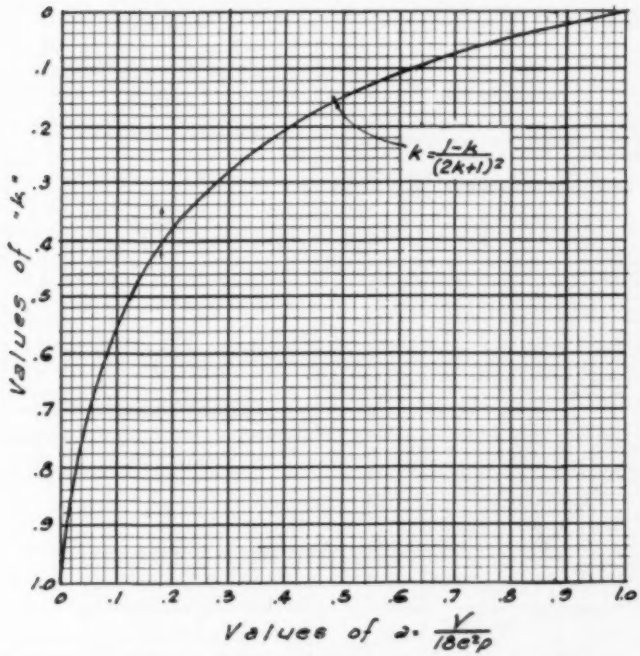


TABLE #2.

"k"	"a"
.0	1.0
.1	.625
.2	.407
.3	.273
.4	.185
.5	.125
.6	.083
.7	.052
.8	.030
.9	.0013
1.0	0

Graph 2 for Case II problems. Overturning on rectangular axis. This graph applies where "a" is 1.0 or less.

$$\int_{eD}^{2eD} \frac{2cD - x}{c^2} \left[pm + p\frac{(1-m)}{2cD} \right] dx$$

When the above integration and substitutions are made the following result is obtained:

$$V = pD^2\left[m + \frac{1}{2}(1-m) \right] \quad (13)$$

The moment of the trapezoidal solid about the Y-Y axis is as follows:

$$M_1 = \int_0^{eD} \frac{x}{c^2} (pm + p\frac{(1-m)}{2cD} dx + \int_{eD}^{2eD} \frac{2cD - x}{c^2}\left[pm + p\frac{(1-m)x}{2cD} \right] \times dx$$

Integrating and substituting between the limits as indicated, the following result is obtained:

$$M_1 = pD^3c\left[\frac{7}{12} + \frac{5}{12} m \right] \quad (14)$$

If the coefficients of pD^2 and pD^3 in Equations (13) and (14) are represented by C_1 and C_2, then these equations may be written as follows:

$$V = C_1pD^2 \quad (13a)$$
$$M_1 = C_2pD^3 \quad (14a)$$

Center of gravity of stress solid.

$$\bar{x} = \frac{M_1}{V} = \frac{C_2pD^3}{C_1pD^2} = \frac{C_2}{C_1} D = C_3D \quad (15)$$

Values of C_1, C_2, and C_3 are found in Table 3 and Graph 3 for the full range of values for m.

$$\bar{x} = .707D + e \quad (16)$$
$$\text{Also } \bar{x} = C_3D \quad (15)$$

Equating (15) and (16) and solving for "D."

$$C_3D = .707D + e$$

TABLE 3—Case I

m	C_1	C_2	$C_3=\frac{C_2}{C_1}$	$a=\frac{C_1}{34.7\,(C_3-.707)^2}$
0	.50	.4124	.827	1.0
.1	.55	.442	.804	1.69
.2	.60	.472	.787	2.70
.3	.65	.501	.770	4.73
.4	.70	.530	.757	7.78
.5	.75	.560	.747	13.5
.6	.80	.588	.735	29.4
.7	.85	.618	.727	61.1
.8	.90	.648	.720	153.1
.9	.95	.677	.712	1090.0
1.0	1.0	.707	.707	∞

$$D=\frac{e}{C_3-.707} \qquad (17)$$

From (13a) $D=\sqrt{\frac{V}{C_1p}}$ (18)

Equate (17) and (18).

$$\sqrt{\frac{V}{C_1p}}=\frac{e}{C_3-.707}$$

Squaring and solving

$$\frac{V}{e^2p}=\frac{C_1}{(C_3-.707)^2} \qquad (19)$$

If each term is represented by "a"

Then $a=\frac{V}{e^2p}$ Also $a=\frac{C_1}{(C_3-.707)^2}$

Divide Equation (19) through by 34.7 so that a = 1.0 when m = 0.

Then $a=\frac{V}{34.7e^2p}$ Also $a=\frac{C_1}{34.7\,(C_3-.707)^2}$ (19a)

Values of "a" are found in Table 3 or Graph 3.

If D is known, to solve for "m" and "p."

From Equation (17), $C_3=\frac{.707\,D-e}{D}$ (17a)

Then with a value of C_3 obtain values of m and C_1 from Graph 3.

From Equation (18), $p=\frac{V}{C_1D^2}$ (18a)

Overturning on Diagonal Axis

Case II. Triangular Earth Pressure

Solid—Volume of Triangular Solid

Two equations are required to determine the volume of the triangular solid, as follows:

For values of k = 0 to k = .5, Figures 3b.

$$V=\int_{2ckD}^{cD}\frac{x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\,dx+\int_{cD}^{2cD}\frac{2cD-x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\,dx$$

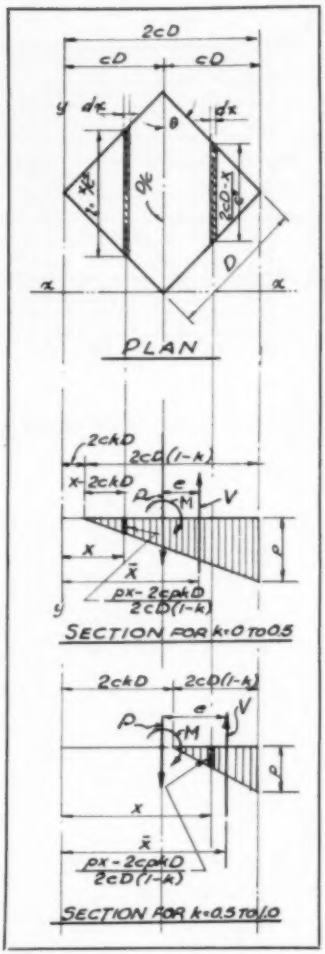
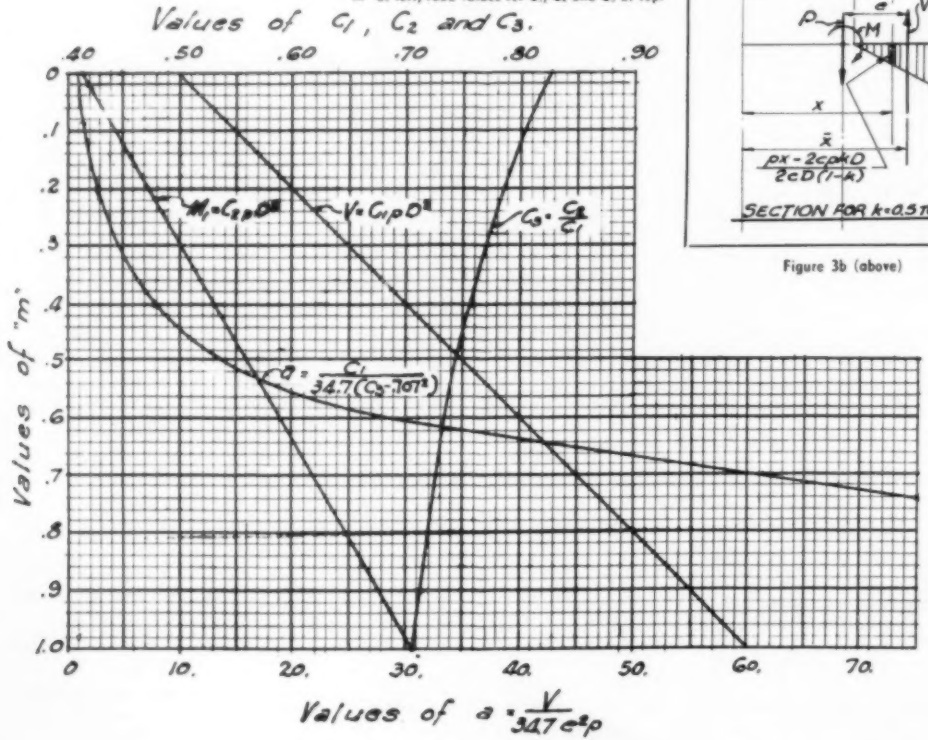
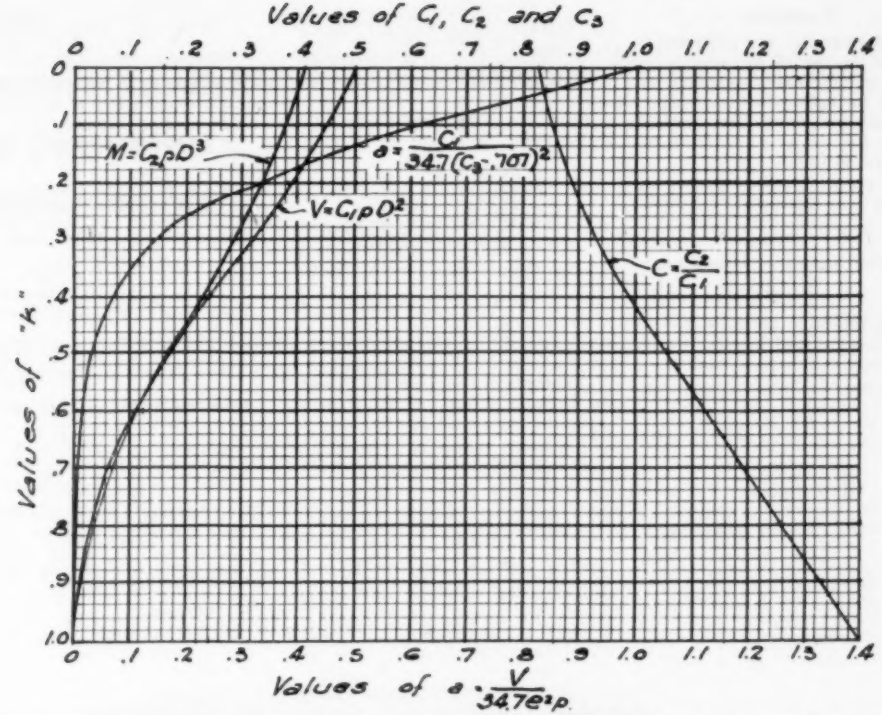


Figure 3b (above)

Figure 3b (at right)

Below—Graph 3 for Case I problems. Overturning on a diagonal axis. Enter graph with a known value of "a" at bottom and read a value of "m" at left. Then with a known value of "m" at left, read values for C_1, C_2 and C_3 at top.





Graph 4 for Case II problems. Overturning on diagonal axis. Enter graph with a known value of "a" and read a value of "k" at left, then with a known value of "k," read values for C_1, C_2 and C_3 at top.

For values of k = .5 to k = 1.0, Figures 3b.

$$V=\int_{2ckD}^{2cD}\frac{2cD-x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\,dx$$

Note $c=\cos\Theta=.707$.

When the above equations are integrated and substitutions made between the limits as indicated, the following results are obtained:

$$V=pD^3\cdot\frac{1}{1-k}\left[\frac{1}{2}-k+\frac{2}{3}k^3\right]$$

For values k = 0 to k = .5 (20)

$$V=pD^3\cdot\frac{1}{1-k}\left[\frac{2}{3}-2k+2k^3-\frac{2}{3}k^3\right]$$

For values k = .5 to k = 1.0 (20a)

Moment of the triangular solid, about the Y-Y axis

For values of k = 0 to k = .5, Figures 3b.

$$M_1=\int_{2ckD}^{cD}\frac{x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\times dx+\int_{cD}^{2cD}\frac{2cD-x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\times dx$$

For values of k = .5 to k = 1.0, Figures 3b.

$$M_1=\int_{2ckD}^{2cD}\frac{2cD-x}{c^2}\cdot\frac{px-2cpkD}{2cD(1-k)}\times dx$$

When the above equations are integrated and substitutions between the limits as indicated, the following results are obtained:

$$M_1=pD^4\cdot\frac{c}{1-k}\left[\frac{7}{12}-k+\frac{2}{3}k^4\right]$$

For k = 0 to k = .5 (21)

$$M_1=pD^3\cdot\frac{c}{1-k}\left[\frac{2}{3}-\frac{4}{3}k+\frac{4}{3}k^3-\frac{2}{3}k^4\right]$$

For k = .5 to k = 1.0 (21a)

If the coefficients of pD^2 and pD^3 in Equations (20), (20a) and (21), (21a) are represented by C_1 and C_2, then these can be combined into one set of equations and simply written as follows:

$$V=C_1pD^2 \qquad (20b)$$

$$M_1=C_2pD^3 \qquad (21b)$$

$$\text{Center of gravity } \bar{x}=\frac{M_1}{V}=\frac{C_2pD^3}{C_1pD^2}=\frac{C_2}{C_1}=C_3D \qquad (22)$$

Values of C_1, C_2 and C_3 are found in Table 4 and Graph 4 for the full range of values for "k."

Case I symbols have been used in the development of formulas for Case II, consequently the formulas are the same. For Case II the values of a, C_1, C_2 and C_3 are to be obtained from Table 4 or Graph 4. The formulas are again listed below.

$$D=\sqrt{\frac{V}{C_1p}} \qquad (18)$$

$$\frac{V}{34.7e^2p}=\frac{C_1}{34.7(C_3-.707)^2} \qquad (19a)$$

See Table 4 and Graph 4 for full range of values.

For the reverse operation, if D is known to solve for k and p.

$$\text{From Equation (17), } C_3=\frac{.707D-e}{D} \qquad (17a)$$

Then with a value of C_3 obtain values of k and C_1 from Graph 4.

$$\text{From Equation (18), } p=\frac{V}{C_1D^2} \qquad (18a)$$

TABLE 4—Case II

k	C_1	C_2	$C_3=\frac{C_2}{C_1}$	$a=\frac{C_1}{34.7(C_3-.707)^2}$
0	.500	.4124	.827	1.0
.1	.445	.379	.852	.612
.2	.382	.341	.894	.340
.3	.311	.292	.940	.150
.4	.240	.237	.990	.0665
.5	.167	.177	1.06	.0396
.6	.107	.1215	1.131	.0173
.7	.060	.0719	1.195	.00727
.8	.0265	.0339	1.275	.00236
.9	.0007	.0092	1.330	.0000518
1.0	0	0	1.414	0

Examples

A few examples are presented to illustrate the use of the graphs and also show how easily solutions are obtained for square footings where a direct load and moment are involved.

Index for use of equations and graphs are as follow:

(a) Moment applied on rectangular axis

Case	Equations	Graphs
I	(1)— (6)	1
II	(7)—(12)	2

(b) Moment applied on diagonal axis

I	(13—19)	3
II	(20—22)	4

In the following examples it is assumed that the load includes footing and moment is at base of footing.

Example 1: Moment acting on rectangular axis:

Given P = 100000 pounds; M = 50000 foot pounds; p = 3000 pounds per square foot.

$$e = \frac{M}{P} = \frac{50000}{100000} = .5'$$

$$a = \frac{V}{18e^2p} = \frac{100000}{18 \times .5^2 \times 3000} = 7.4 > 1.0 \text{ Case I problem}$$

From Graph 1 when a = 7.4 m = .395

$$D = \sqrt{\frac{2V}{p(1+m)}} = \frac{2 \times 100000}{3000 \times 1.395} = 6.91 \text{ feet square}$$

Example 2: Moment on rectangular axis:

Given P = 100000 pounds; M = 200000 foot pounds; p = 3000 pounds per square foot.

$$e = \frac{200000}{100000} = 2'\text{-}0$$

$$a = \frac{V}{18e^2p} = \frac{100000}{18 \times 2^2 \times 3000} = .463 < 1.0 \quad \text{Case II problem}$$

From Graph 2 when a = .463 k = .162

$$D = \sqrt{\frac{2V}{p(1-k)}} = \sqrt{\frac{2 \times 100000}{3000 \times (1 \times .162)}} = 8.91 \text{ feet square}$$

Example 3: Suppose the moment in Example 2 acts on the diagonal axis; the size would then be:

P = 100000 pounds, M = 200000 foot pounds, p = 3000 pounds per square foot, e = 2'-0.

$$a = \frac{V}{34.7e^2p} = \frac{100000}{34.7 \times 2^2 \times 3000} = .24 < 1.0 \quad \text{Case II problem}$$

From Graph 4 when a = .24 k = .25 and C_t = .35.

$$D = \sqrt{\frac{V}{C_t p}} = \sqrt{\frac{100000}{.35 \times 3000}} = 9.75 \text{ square} \quad kD = .25 \times 9.75 = 2.43'.$$

Example 4: A method for obtaining approximate size of footing from column load and moment.

Column load 300,000 pounds, moment 400,000 foot pounds acting on diagonal axis. e = 1.33 feet.

Net soil pressure 4000 pounds per square foot less 500 pounds per square foot for weight of footing and soil overburden = 3500 pounds per square foot.

$$a = \frac{300000}{34.7 \times 1.33^2 \times 3500} = 1.62 > 1.0 \quad \text{Case I problem}$$

From Graph 3 when a = 1.62, m = .10, C_t = .55.

$$D = \sqrt{\frac{V}{C_t p}} = \sqrt{\frac{300000}{.55 \times 3500}} = 12.5 \text{ feet}$$

Estimated weight of footing and overburden = 45000.

$$\text{Then } a = \frac{345000}{34.7 \times 1.16^2 \times 4000} = 1.84$$

Then m = .12 and C_t = .56

$$D = \sqrt{\frac{345000}{.56 \times 4000}} = 12.4 \text{ feet.}$$

REFERENCE

[1]Fork, Charles H. "Graphical Methods Aid In Stack Foundations Design." Petroleum Refiner, **30**, No. 3, 81-5 (1951).

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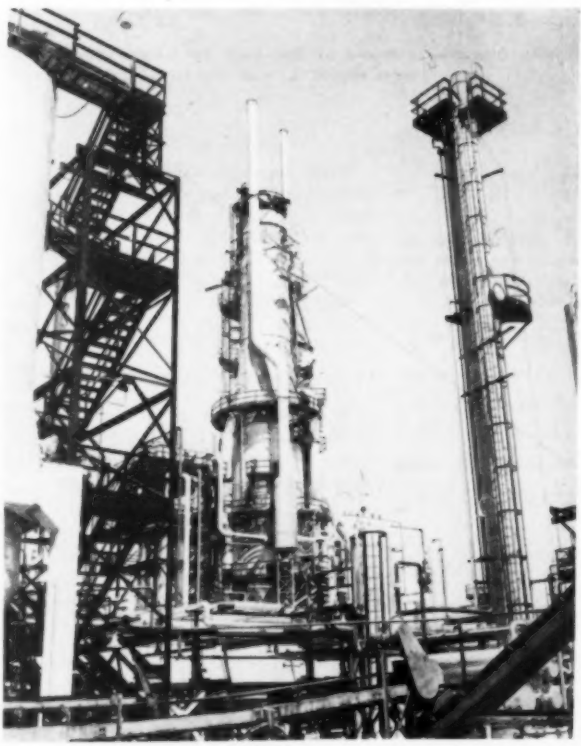

A First

Saskatchewan's first catalytic cracking unit, at the right, is used in the manufacture of high-octane gasoline for The British American Oil Company Limited. The cat cracker and the debutanizer on the right are part of the recently completed expansion and modernization program at British American Oil's Moose Jaw refinery.

Thermal Insulation For Industrial Requirements

Part VIII. Design considerations in the use of thermal insulation. How use of metallic materials in reflective insulation is gaining wide attention.

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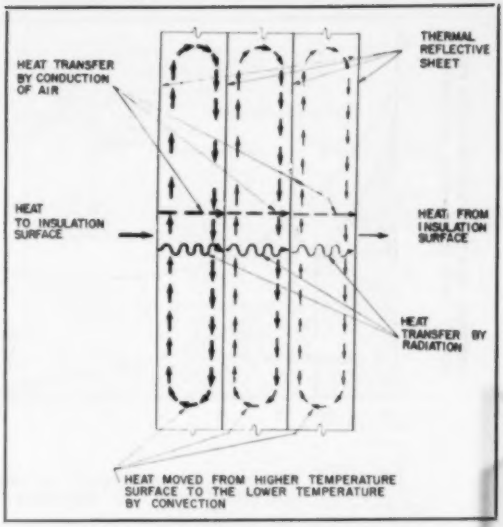
HEAT TRANSFER BY CONDUCTION OF AIR
THERMAL REFLECTIVE SHEET
HEAT TO INSULATION SURFACE
HEAT FROM INSULATION SURFACE
HEAT TRANSFER BY RADIATION
HEAT MOVED FROM HIGHER TEMPERATURE SURFACE TO THE LOWER TEMPERATURE BY CONVECTION

Figure 1. Heat transfer through reflective insulation.

THE MOST recent information on the use of metallic materials for reflective insulation is presented in this chapter. These materials are gaining in popular acceptance as a result of fairly recent developments in application.

Too frequently we become a victim of complacency and because of our trust in the performance of a product in current use we deny ourselves the knowledge of potentially better products and their sources. This lack of curiosity often results in missed opportunities, not only for improvement, but for the use of alternative or substitute materials. The need for such information may be serious during a shortage of frequently used commodities.

Some metals, due to their particular properties, are peculiarly adaptable for use in reflecting heat. Not all of these metals retain all properties to the same degree. Several may perform in a highly satisfactory manner while new, but lose some of their effectiveness in due time. This loss is due primarily to a change on the surface resulting in a reduction of the reflective value. It must be stressed however, that although the surfaces of all materials are affected, some are influenced to such a slight degree that for all practical purposes they retain their essential surface properties.

Although this series of articles is written under the title of "Industrial Insulation" it applies equally well to all phases of thermal insulation applications. Any differences lie in the modifications required to comply with design requirements.

The industrial applications of reflective thermal insulation have been relatively infrequent up to the present time. To a great degree this is due to the lack of knowledge regarding the function of this type of insulation. In certain applications reflective thermal insulation can be used to greater advantage than any mass type insulation. One particular characteristic which may be of importance is that reflective insulation has low heat storage capacity as compared with mass insulation.

Basic Factors of Heat Transfer

In our consideration of the way in which reflective insulation functions it is well to first review the basic factors of heat transfer. Heat is transferred by radiation and conduction, and the definitions of these methods of heat transfer are as follows:

Radiation is heat transmission through space from a body at a higher temperature to a body at a lower temperature.

Conduction is heat transmission by direct contact from one body at a higher temperature to a body at a lower temperature, or the transmission from a higher temperature region to a lower temperature region within the same body.

Although convection is often referred to as being a means of heat transmission, fundamentally it is a movement of mass (generally gas or liquid) to which heat has been transmitted by radiation and conduction. The definition of convection is as follows:

Convection is movement of a body from one position to another, without heat transformation. For example, air in contact with a pipe of a higher temperature is heated by conduction. Its movement away from the contact surface is by convection.

However this phenomenon must be considered as part of the total amount of heat transmitted and moved away. For this reason and for ease in calculation, convection is commonly termed and used as heat transmission and will be spoken of as such in this chapter.

Reflective insulation must present a resistance to heat transmission by radiation, conduction, and convection. Figure 1 illustrates the heat transfer through reflective insulation by these three mediums. The manner in which the resistance to heat flow is accomplished will be treated, beginning with the transmission of heat by conduction.

Heat will be transmitted from one sheet to another by conduction through air. However, when radiation is not considered, still air will only conduct, at atmospheric temperatures, approximately 0.16 Btu per SF, per inch thickness, per °F. temperature difference. This is a relatively small quantity, therefore the amount of heat transferred by conduction, though it adds to the total, will not be excessive.

Convection air currents will move heat from the higher temperature surface to the lower temperature surface. This movement however is normally upward because of the lighter density of the warmer air. When the reflective surfaces or sheets are placed in a vertical position convection currents move more rapidly, thus will move more heat to the lower temperature surface than the sheets (or spaces between

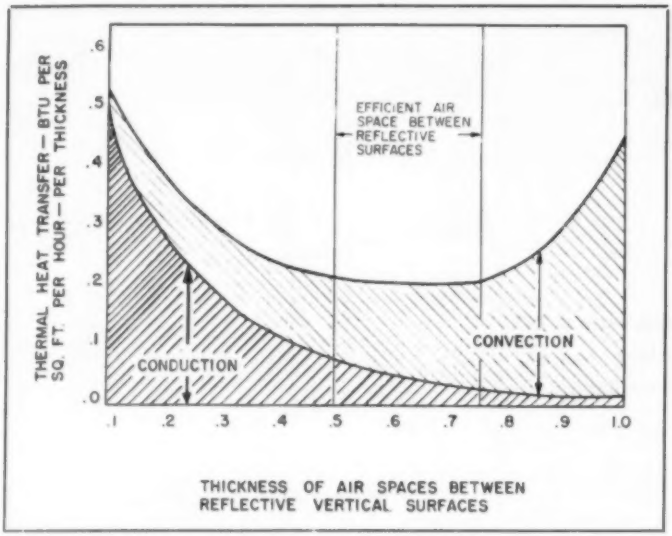

Figure 2. Heat transfer by convection and conduction for various air spaces.

them) in a horizontal plane. For this reason heat movement by convection must be considered more carefully when the sheets and spaces are located vertically. Air movement by convection can be restricted by reducing the size of the air space. The smaller the air space the greater the resistance to convection air movement, therefore less heat is moved from one surface to another. Unfortunately as the air space is reduced the heat transferred by conduction through the air will increase, thus the proper air space must be determined for its greatest effectiveness. The heat transfer by conduction and convection for various air spaces are plotted on Figure 2. The point at which the combined heat transfer is the lowest determines the vertical spacing for best efficiency. This is indicated to be a $\frac{1}{2}$ to $\frac{3}{4}$-inch thickness air space between sheets.

Because the amount of heat which passes across the air space by conduction will be small and the amount which is moved by convection can be kept small by proper spacing, the only other means by which heat can pass through the air space is by radiation. This rate of heat transmission across an air space may be quite large. It can be reduced by the use of sheets which reflect heat in a manner similar to which a mirror reflects light. Light reflection and heat reflection are, however, not the same. A metal may be an excellent heat reflector, but a poor light reflector.

Up to this point the property of a material to turn heat away from its surface has been designated as reflectivity, but in the calculation of heat transfer, surfaces are evaluated as to their emissivity. Since all surfaces are compared to a perfectly black body

Chart A—Emissivity

METAL	Highly Polished	Oxidized
Aluminum	0.05	0.11
Brass	0.03	0.61
Copper	0.03	0.71
Iron	0.29	0.73
Sheet Steel	0.55	0.82
Lead	0.07	0.63
Nickel	0.05	0.

(one which reflects no heat) the emissive power of any body is equal to its absorptivity multiplied by the total emissive power of a black body at that temperature. It therefore follows that:

Emissivity is the ratio of the total emissive power of any body to the total emissive power of a black body at the same temperature.

Although most metals have a low emissivity when their surface is clean, bright and polished, the emissivity rises when the surface becomes dull and oxidized. Chart A is of a general nature and while not specific enough for particular conditions, does show general relationships between various metal surfaces, before and after the surface is oxidized.

If it were possible to keep the surface of brass, copper, lead, and nickel polished and free of oxide, they would make excellent reflective sheets. Aluminum, however, can have a bright surface or an oxidized surface and still maintain a low emissivity. For this reason, in many installations, an aluminum surface is the most logical metal to use as reflective thermal insulation.

Reflective thermal insulation can be used to insulate equipment and piping operating at low temperatures, but, as is the case of all low temperature installations, it must be sealed on the higher temperature side to provide a vapor barrier to prevent condensation of moisture from entering within the air spaces.

Reflective thermal insulation can also be used to insulate equipment and piping operating at high temperatures.

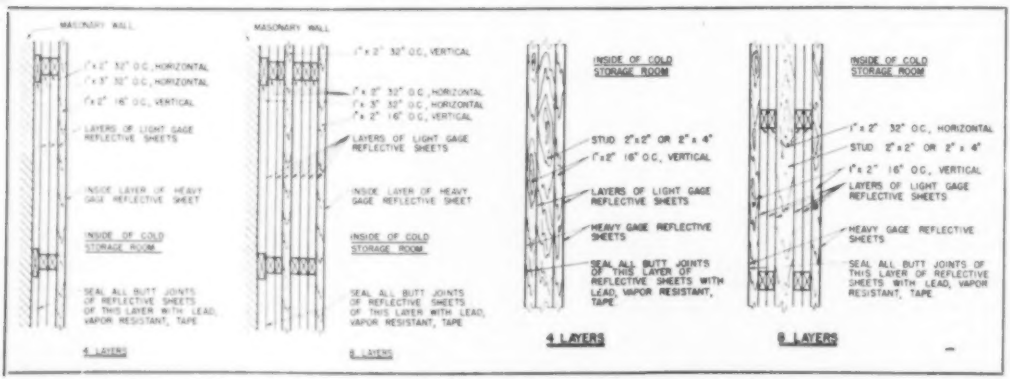
MASONRY WALL
1" x 2" 32" O.C. HORIZONTAL
1" x 3" 32" O.C. HORIZONTAL
1" x 2" 16" O.C. VERTICAL
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
INSIDE LAYER OF HEAVY GAGE REFLECTIVE SHEET
INSIDE OF COLD STORAGE ROOM
SEAL ALL BUTT JOINTS OF REFLECTIVE SHEETS OF THIS LAYER WITH LEAD, VAPOR RESISTANT, TAPE
4 LAYERS
MASONRY WALL
1" x 2" 32" O.C. VERTICAL
1" x 3" 32" O.C. HORIZONTAL
1" x 2" 16" O.C. VERTICAL
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
INSIDE LAYER OF HEAVY GAGE REFLECTIVE SHEET
INSIDE OF COLD STORAGE ROOM
SEAL ALL BUTT JOINTS OF REFLECTIVE SHEETS OF THIS LAYER WITH LEAD, VAPOR RESISTANT, TAPE
8 LAYERS

Figure 3. Application of reflective insulation to masonry walls.

INSIDE OF COLD STORAGE ROOM
STUD 2"x2" OR 2"x 4"
1"x2" 16" O.C. VERTICAL
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
HEAVY GAGE REFLECTIVE SHEETS
SEAL ALL BUTT JOINTS OF THIS LAYER OF REFLECTIVE SHEETS WITH LEAD, VAPOR RESISTANT, TAPE
4 LAYERS
INSIDE OF COLD STORAGE ROOM
1" x 2" 32" O.C. HORIZONTAL
STUD 2"x2" OR 2" x 4"
1"x 2" 16" O.C. VERTICAL
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
HEAVY GAGE REFLECTIVE SHEETS
SEAL ALL BUTT JOINTS OF THIS LAYER OF REFLECTIVE SHEETS WITH LEAD, VAPOR RESISTANT, TAPE
8 LAYERS

Figure 4. Application of reflective insulation to "free standing" stud wall.

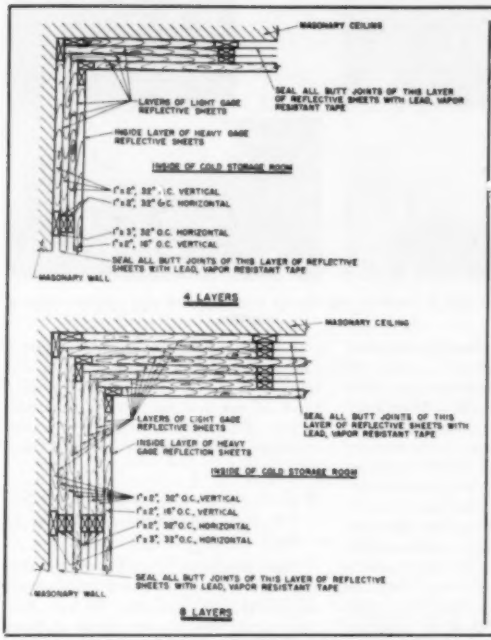
MASONRY CEILING
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
SEAL ALL BUTT JOINTS OF THIS LAYER OF REFLECTIVE SHEETS WITH LEAD, VAPOR RESISTANT TAPE
INSIDE LAYER OF HEAVY GAGE REFLECTIVE SHEETS
INSIDE OF COLD STORAGE ROOM
MASONRY WALL
4 LAYERS
MASONRY CEILING
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
SEAL ALL BUTT JOINTS OF THIS LAYER OF REFLECTIVE SHEETS WITH LEAD, VAPOR RESISTANT TAPE
INSIDE LAYER OF HEAVY GAGE REFLECTION SHEETS
INSIDE OF COLD STORAGE ROOM
MASONRY WALL
8 LAYERS

Figure 5. Application of reflective insulation at intersection of masonry wall and ceiling.

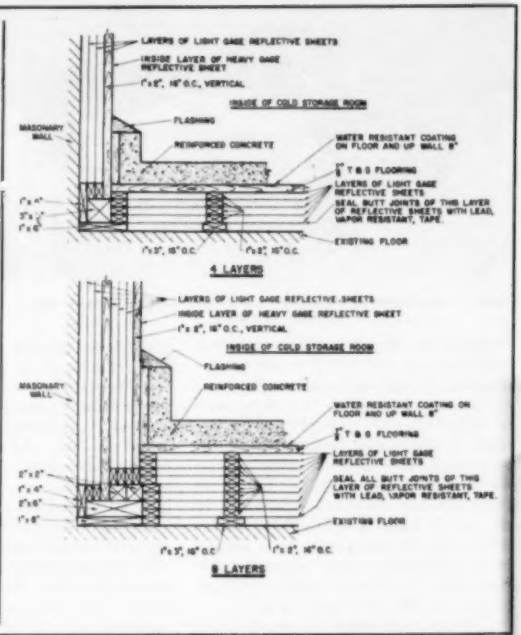
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
INSIDE LAYER OF HEAVY GAGE REFLECTIVE SHEET
INSIDE OF COLD STORAGE ROOM
FLASHING
MASONRY WALL
REINFORCED CONCRETE
WATER RESISTANT COATING ON FLOOR AND UP WALL 8"
LAYERS OF LIGHT GAGE REFLECTIVE SHEETS
SEAL BUTT JOINTS OF THIS LAYER OF REFLECTIVE SHEETS WITH LEAD, VAPOR RESISTANT, TAPE
EXISTING FLOOR
4 LAYERS
8 LAYERS

Figure 6. Application of reflective insulation at intersection of floor and masonry wall.

Insulation on equipment or piping operating at higher than atmospheric temperatures, of course, require no outer vapor membrane sealing. This type of thermal insulation can be used on operating temperatures close to the softening point of the reflective sheet.

Because of previous difficulty of vapor sealing curved segments on the outer surface of equipment and pipe insulation, reflective insulation has not been used on a large scale for insulating low temperature industrial equipment and piping. However a method for sealing the outer layer with vapor resistant tape, especially lead, has made the use of reflective insulation for cold storage rooms very practical, and this use of reflective insulation tape is now used in industrial piping and equipment applications.

Reflective insulation may be used to advantage in the insulation of all types of buildings. In addition to its use as an insulation in building walls and ceilings it may also be used as a vapor barrier.

Reflective Thermal Insulation of Cold Storage Rooms

Thickness and density determine the resistance to heat flow of mass insulation, while the number of reflective surfaces and spacing determine the resistance to heat flow when reflective thermal insulation is used. The difference in temperature from the outside to the inside will determine the necessary resistance to the heat transfer. Considering the atmospheric temperature to be about 75 F. and other conditions to be moderate, Table 1 may be used as a guide for the number of reflective sheets required to insulate a cold storage room for the listed operating temperatures.

The reflective sheets of insulation should be of a metal which will reflect approximately 95 percent of the radiant heat and have a corresponding emissivity of 0.05 when it is new. After prolonged exposure in a location under use it should retain at least 95 percent of its value as a heat insulation. The sheets should be furnished in a form and width suitable for the intended installation. A thin gage metal should be used for intermediate layers and a heavier gage for the outermost or innermost layer which may be subjected to physical abuse.

A vapor barrier seal on the warm side should be accomplished by the use of a lead or equally effective tape to cover all butt joints of the reflective sheets on this warm side layer. The tape should be furnished in rolls of suitable width, vapor resistant, with a pressure sensitive adhesive on one side.

Wood spacer strips, approximately 1 x 3 inches are usually applied directly on existing walls and shimmed level. The vapor barrier sheet is then stapled directly to the face of the wood strips, used for support of the butt joints of all sheets. The vapor barrier tape is applied over all butt joints of the heavy sheet, to form an unbroken vapor barrier on the warm side only. Succeeding spacer strips are usually 1 x 2 inches and are applied directly over the 1 x 3 inch strips, over which the second layer of reflective sheets is stapled to the spacer strips. Subsequent layers are applied in like manner except that strips supporting the last, or innermost, are applied vertically instead of horizontally. If more than 4 layers are used the center layer is also applied with the strips in a vertical position. Vertical stripping reduces through conduction of the wood to a minimum and at the same time strengthens the construction. The last layer of metal, which may be subjected to mechanical abuse, should be of sufficient thickness to withstand the physical load imposed upon it. Recommended details of construction are shown in Figure 3.

Table 1

Temperatures of Cold Storage Room in °F.	Number of Sheets of Reflective Insulation		
	Ceiling	Walls	Floor
Plus 40 to Plus 20	3	4	4
Plus 29 to Plus 11	3	5	5
Plus 10 to Minus 9	4	6	6
Minus 10 to Minus 19	5	7	7
Minus 19 to Minus 29	6	8	8

Figure 7. Application of reflective thermal insulation on roof of cold storage warehouse.

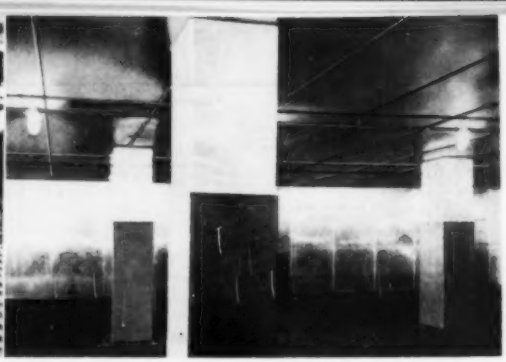

Figure 8. Inside of cold storage room insulated with reflective thermal insulation.

Reflective sheets applied to stud walls can be stapled directly to the wood studs and continued in the manner as previously described. Strips can be nailed directly to each side of the studs if necessary to obtain plumb alignment. The outside layer on the warm side should be vapor sealed to form the necessary vapor barrier. If the outside layer is subjected to abuse, it too, like the innermost layer should be of sufficient gage to resist damage. Recommended details of this construction are shown in Figure 4.

Ceilings supported by wood joists should be constructed in the same manner as shown for stud walls with wood spacer strips attached to the joists instead of the studs.

Insulation attached to existing masonry ceilings should be installed in a manner similar to that described for the insulation of masonry walls. Other than the special care which must be taken to secure the first spacer strip to the ceiling the balance of the insulation will follow as previously specified. The junction of the walls with the ceiling should be installed with extreme care as shown in Figure 5.

Wood spacer strips 1 x 3 inches should be installed on existing wood sub floor, 16 inches on center. Reflective sheets can then be stapled on these strips with all butt joints sealed with vapor resistant tape. One x 2-inch wood strips are applied directly over the 1 x 3-inch strips as directed for walls and ceiling. A tongue and groove wood flooring, 7/8-inch thick must be laid on top of the last wood spacers to support the finished floor. A water resistant coating applied over the wood flooring and extended up the cove base at least six inches will protect the dry materials underneath. A concrete slab, of the thickness required and properly reinforced with steel, can then be poured over this area. Details of this construction and method of installation at the junction of the floor and wall are shown in Figure 6.

In some cases the complete roof of cold storage plants are insulated instead of individual rooms. Figure 7 shows such an application of reflective insulation.

Figure 8 shows the interior of a cold storage room insulated with reflective insulation.

The specifications for insulating cold storage rooms, and the use of reflective insulation given in this article are by necessity very general in nature. The drawings which show four and eight reflective sheets were chosen just as a matter of illustration. For any particular installation the number of sheets must be determined by the insulation requirements. Again, the use of reflective sheet insulation is not restricted just to cold storage installations, but may be used to advantage in other types of applications. One such application, shown in Figure 9, is a test chamber which operates at dual temperatures.

Reflective Thermal Insulation of Piping and Equipment Operating at High Temperatures

Pipe insulation consists of formed resilient sheets of heat-reflective metal, separated and reinforced by low thermal conductive spacers so as to form isolated air chambers. The spacer on one end is recessed so that the adjoining section of pipe insulation will telescope to the spacer forming an overlap of outer layer metal.

Curved or flat segments to fit equipment are fabricated in the same manner as the sectional pipe insulation. Both the pipe insulation and flat or curved segments are fabricated with light-weight metal on the inner sheets and with a thicker gage metal on the outside to resist mechanical abuse. Shown in Figure 10 is a section of reflective pipe insulation and in Figure 11 a curved segment of reflective insulation to fit a piece of equipment.

The number of reflective layers commonly furnished is from 2 to 9 depending upon the installation require-

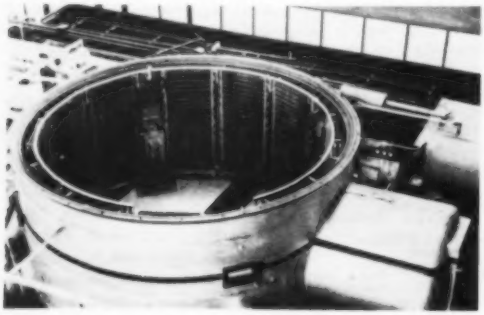

Figure 9. Dual temperature test chamber insulated with reflective thermal insulation.

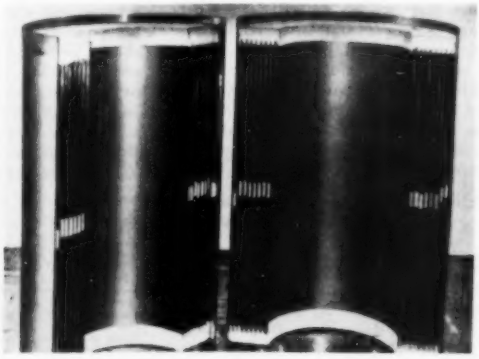

Figure 10. Reflective thermal pipe insulation.

Chart B

Number of Reflective Sheets, or Thickness, Required to Insulate Piping Operating at Temperatures as Listed

Temp. °F.	Pipe Size, Inches	Number of Reflective Sheets	Insulation Thickness in Inches
901 to 1050	1½ and under	5	2½
	2 to 6	8	4
	8 and over	9	4½
801 to 900	1½ and under	4	2
	2 to 6	7	3½
	8 and over	8	4
701 to 800	1½ and under	4	2
	2 to 6	6	3
	8 and over	7	3½
601 to 700	1½ and under	3	1½
	2 to 4	5	2½
	5 and over	6	3
501 to 600	4 and under	3	1½
	5 to 8	4	2
	10 and over	5	2½
401 to 500	4 and under	3	3
	5 and over	2	4
301 to 400	1½ and under	2	1
	2 to 8	3	1½
	10 and over	4	2
201 to 300	8 and under	2	1
	10 and over	3	1½
Atmos. to 200	All sizes	2	1

ments. Except in special instances this insulation is made with two layers of reflective sheet per inch of thickness. Chart B is given to serve as a guide for the number of spaces required for various operating temperatures. A common practice of designating the amount of insulation in inches of thickness, as well as number of reflective sheets is shown.

In addition to being furnished in pipe and segmental insulation this reflective insulation is also manufactured to fit valves, ells, tees and flanges. However, when such fitting covers are used it is difficult to make satisfactory adjustments for errors in dimensions. Therefore exact piping details must be known by the manufacturer to obtain proper fits for ease of application. Likewise the insulation must be fabricated to fit the equipment to which it is to be applied and exact outside dimensions of the equipment must be furnished to the supplier.

Application

In general, each pipe insulation section and each fitting cover is a two-piece unit. The two halves of a pipe section are placed over the pipe and secured in place with bands or snap-type fasteners. Adjacent pipe insulation sections are placed on pipe in same manner and in such a way that recessed spacer butts against the flush spacer of the pipe insulation section already in place. Outer layer metal will thus overlap at each end joint.

Fitting sections are applied in same general manner and are also secured by bands, screws, or snap-type fasteners. Figure 12 shows application of reflective insulation to pipe, ells, tees, and valves.

Curved and flat segments for insulation of equipment are installed similarly to pipe insulation. Outer layer of metal should overlap at all butt joints and, if outside, should be placed so as to shed rain. Equipment insulation is secured in place with bands, screws or snap-type fasteners.

Where used outdoors, in most instances where the reflective sheets are of aluminum, the insulation needs no special weather barrier or jacket. However, in some instances where conditions may be detrimental to the metal, a suitable coating or jacket may be necessary for the protection of the insulation.

In the past the application of prefabricated reflective insulation has been concentrated on insulation of high temperature piping. Now that a satisfactory method of outside sealing and spacers which combine low conductivity with vapor and moisture resistance have been developed, it may well be that within a short time reflective insulation may be used extensively on low temperature applications.

Figure 11. Reflective thermal equipment insulation.

Reflective insulations will be used more and more for applications where their particular properties may be used to advantage. Their lack of use thus far, in many instances, is due to lack of information available, lack of knowledge as to their characteristics and lack of proper methods to calculate the heat transfer expected.

It is hoped that through these pages there may be revealed a source from which materials, not included in our daily concept of thermal insulating materials, may be drawn to assist in solving those problems which plague us. No material is a cureall, but the greater the variety, the better enabled we are to select one most suitable for the required service. The materials referred to in this chapter have been widely used for the weather protection of thermal insulating materials, and in contrast with most materials used for this purpose, they have the added advantage of reflecting solar heat thereby assisting in the effect on overall heat transfer. By extending its use as herein outlined, dual service is obtained where required.

Much remains to be done in the development of reflective type materials, either in themselves, or in combination with mass types. Being one of the newer entries in the field of thermal insulation greater emphasis should be placed on seeking out those special conditions where such materials can perform more effectively. This brief discussion, while in no sense complete, can be the means of illustrating the possibilities of research and development of metal types.

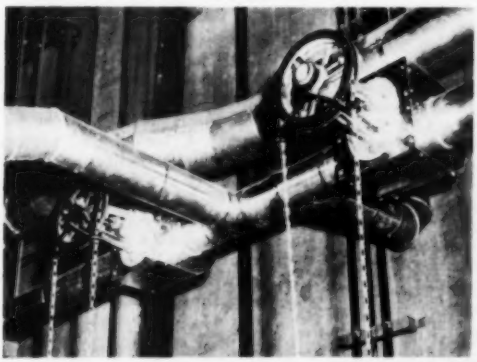

Figure 12. Reflective thermal insulation on pipe ells, tees and valves.

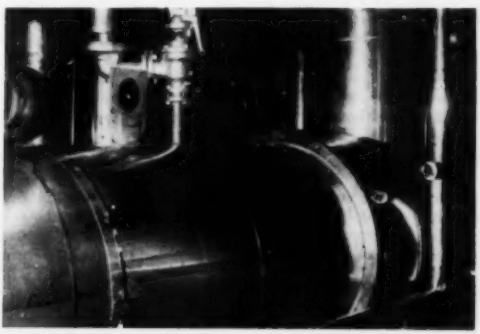

Figure 13. Reflective thermal insulation on equipment.

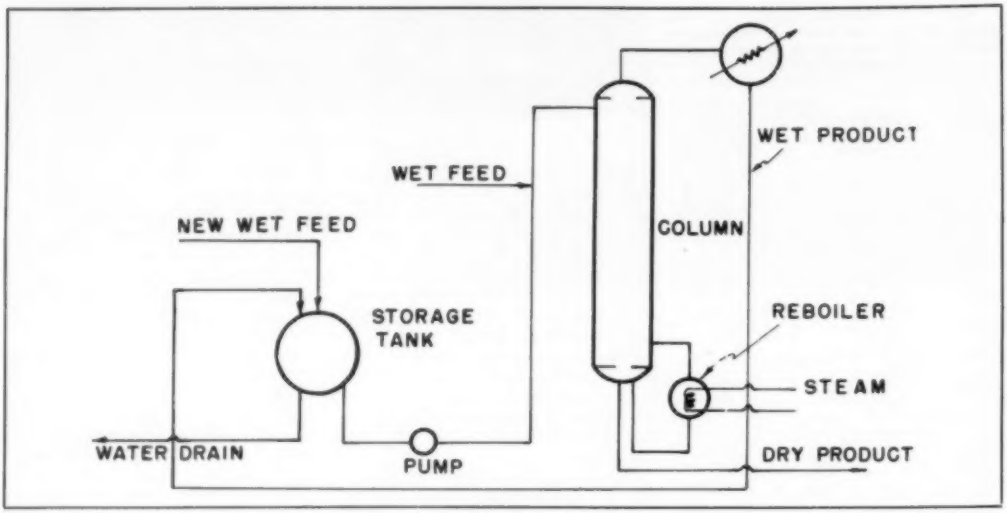

Figure 1. Dehydration column flowsheet.

Applied Distillation

Part III. Dehydration Columns and Steam Distillation. High points of distillation are applied to actual practice to give familiar approach to this unit operation.

K. E. Coulter
The Dow Chemical Company
Midland, Mich.

IN MANY CASES water, in concentrations less than 2 weight percent, must be removed from organic compounds so they can be reacted, refrigerated, alkylated, etc. Water can be removed in a column of the type shown in Figure 1. New feed enters the system at the combination feed tank and water decanter and is pumped to the top of the column. A feed preheater may or may not be used. Feed is warmed in the column from tank temperature to column top temperature causing vapors to condense when no preheater is used. The condensed vapor (induced reflux) and the feed are the liquid stream in the column. After reaching the reboiler a portion of the liquid, equivalent to the induced reflux and overhead vapor, is revaporized and the remainder is dried product. Dried product may contain as low as 1 ppm of water.

Overhead vapor leaves the column, passes through a condenser to the original feed tank, used as a decanter for recycle liquid and new feed. Water may be removed from top or bottom of the tank, depending on the specific gravity of the material being dried. Usually small quantities of water are handled and decantation is periodic. Steam to the reboiler is usually maintained by a steam flow controller or a pressure controller.

The phase diagram, for the process, may be as shown in Figure 2 where T_1 is the temperature of the combination decanter and feed tank, T_2 the steam distillation temperature, T_3 the boiling point of the organic compound and T_4 the boiling point of pure water at the pressure of the system. Line $B\,I$ is the solubility line of water in the organic compound from temperature T_1 to T_2 and $J\,I$ the solubility of water in the organic compound at feed tank temperature T_1. Line $B\,D$ represents liquid compositions in equilibrium with vapors of the compositions below the line $C\,D$ i.e., at T_3 a liquid of composition K would be in equilibrium with vapor of composition L. Line $C\,B$ represents the range of concentrations, at T_2 which will steam distill. Steam distillation temperature may be defined as the temperature at which the sum of the vapor pressure of pure water and pure organic compound equals the pressure of the system. The diagram to the left of C could be described as above except that water is the major component instead of the organic compound.

In the case shown on the flow sheet the feed at composition I would boil at a T_3 and the vapor composition could theoretically be L or M. In actual practice the composition will be between L and K because 100 percent plate efficiency is unlikely and the unit will not be at total reflux. Figure 2 may be used to calculate the minimum quality of recycle liquid when liquid of composition D is removed as bottoms product. With feed composition I or K the ratio of recycle liquid to bottoms product is KE/LK

$$\frac{KE}{LK} = \frac{\text{Quantity of recycle liquid}}{\text{Quantity of bottoms product}}$$

or minimum percentage of feed which

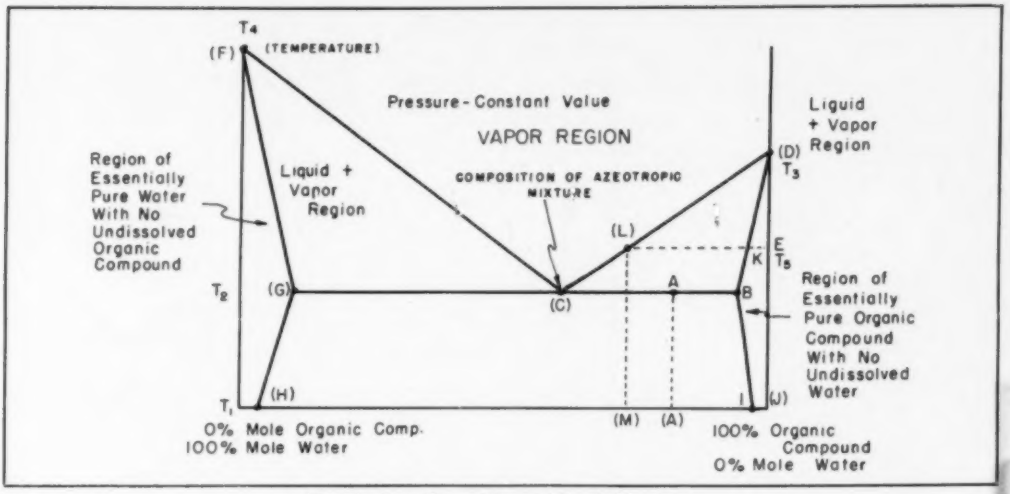

Figure 2. Phase, Diagram for partially miscible system.

must be taken overhead is $\frac{KE(100)}{LE}$

As vapor of composition *L*, removed as overhead, cools in the condenser to T_2 it flows as a two phase liquid to the combination decanter and feed tank. The two phase liquid has one layer of composition *I* and one of composition *H* at temperature T_1. In the temperature range between T_5 and T_2 the material of composition *L* existed partially as liquid and partially as vapor. At T_1 the ratio of the quantity of material of composition *I* to the quantity of composition *H* is HM/MI.

Laboratory data[2] and literature data[3] has shown benzene, hexane, carbon tetrachloride, ethylbenzene and ethylene dichloride can be dried to water concentrations of less than 3 ppm. Slightly more than theoretical distillate was removed in each case. In all of the cases mentioned, the columns operated at plate efficiencies varying from 5 to 25 percent, the reason for low values being uncertain at the present time. Experience obtained testing drying columns has shown extreme sample care must be taken because air in sample bottles and exposure to air can give erratic results and lead to high water contents. Samples should be obtained with dry containers, valved at both ends, so air never contacts the sample. The same precautions must be taken during analyses of the samples.

Steam Distillation

Steam distillation will be defined as an operation in which live steam is introduced in the bottom of a distillation column. The compound in the column may be soluble or insoluble in the water. Steam distillation of compounds which are soluble in water is widely practiced. A few examples are ethyl alcohol, methyl alcohol, aldehydes, oxides, etc. If the compounds are soluble in water they must boil below 100 C. or the use of open steam is impossible. If the compound boils above 100 C. the water will be the overhead product. The use of steam in this manner is referred to as open steam whereas heat supplied from steam but through reboiler tubes is called closed steam. Open steam distillation on water soluble compounds has the advantage that no reboiler is needed, which lowers the investment cost and maintenance costs. It is highly useful on compounds which corrode reboiler tubes or form scale which lowers the heat transfer coefficients. Tar forming materials which lower heat transfer coefficients can also be dealt with by open steam distillation. A disadvantage of open steam is the condensate is usually unsuitable for recycling to boilers and in some cases may be a disposal problem.

The flow sheet, controls, etc., are much the same as shown in previous articles except the reboiler is usually omitted. Instruments, auxiliaries, concentration, and temperature gradients are the same for open or closed steam. Since distillations of this type usually have water in the feed, the efficiency of the column is usually the same for open or closed steam.

Steam distillation of water insoluble materials is an entirely different distillation from the standpoint of theory, controls, efficiencies and auxiliaries. The type of compounds referred to are carbon tetrachloride, benzenes, chlorobenzenes, alkylbenzenes, etc., which are nearly insoluble in water. In this type of distillation the materials distill at the temperature where the sum of the vapor pressure of water and organic compound equals the pressure on the system. For example, at 84 C. water has a vapor pressure of 430 mm mercury and toluene (B. P. 110 C.) a vapor pressure of 330 mm mercury meaning at atmospheric pressure toluene would distill at 84 C. Toluene would distill in the ratio of 430 moles of water to 330 of toluene. The weight ratio would be 0.256 pounds of water per pound of toluene.

Steam distillation of insoluble compounds is often practiced where the compounds are subject to deterioration caused by overheating or where corrosion or fouling of reboilers occur. Limitations are as the boiling point of the compound increases the amount distilled per pound of steam used may become negligible and the over-all cost prohibitive. Steam distillation of insoluble compounds may be practiced using a flowsheet similar to the one on Figure 3. As noted feed enters the column at the side and open steam at the bottom. Component A is taken overhead with water and component B as residue with water. The overhead is separated from the water and part returned as reflux and part as distillate. The water is discarded except in a few cases. In several instances where a slight solubility occurred the water was also returned as reflux, but this has no effect on the separation; in fact the water may lower the tray efficiency. The residue may be separated from the water or may be fed to another column without a separation.

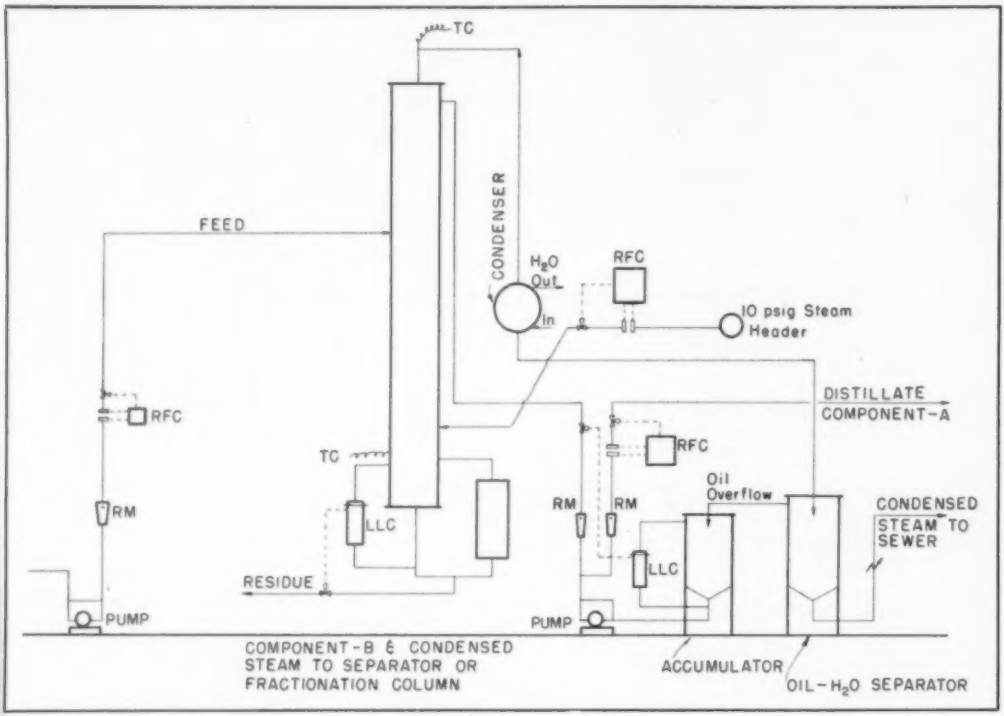

Figure 3. Steam Fractionation flowsheet.

If a dry distillate or residue product is desired a drying column or solid adsorbent can be used.

In a number of cases, water and organic compounds may not separate in the residues from the still. The presence of tars, polymers, inorganic salts, etc., may cause emulsions which will not separate on months of standing or by centrifuging. The emulsions usually consist of small droplets of organic compound dispersed in the water. The oil industry has resorted to demulsifying agents and glass wool filters to break the emulsions.[2] In practice the author has found it best to feed troublesome residue emulsions to the following column and handle it in the same manner as a decanted residue. This eliminates the residue decanter and adds a larger water load to the column but if the residue is fed direct, without cooling or inventorying, the column heat load is not materially increased. The volatile material is distilled from the emulsified feed and usually separates from the distillate unless the impurities causing the emulsion are volatile.

In open steam distillation of nearly insoluble organic compounds, steam is condensed in the tower by the addition of cold feed, cold reflux, vaporization, and heat losses through the insulation. The condensed steam appears as water in the residue and when no decanters are used on the intermediate stills it appears as water in the residue from the final still. In a few cases in the plant the quantity of water in the residue was high and the residue could not be dumped to the sewer. In the cases mentioned the material was trucked by dumpsters and the water content was too high for burning. To render the material burnable and to reduce trucking costs a horizontal tubular reboiler was installed at the base of the still and a portion of the water revaporized. The reboiler tubes were readily removable and with reasonable water content in residue, fouling was almost eliminated.

Condensers on units of this type are usually larger than those where dry diltillation is practiced. The reason is water has a latent heat of vaporization of 900 to 1000 Btu per pound and organic compounds a value of around 150. When large quantities of water distill with the organic compounds condensers and condenser loads become large.

Concentration gradients appear the same as for dry distillation but temperature gradients differ. For example, if alkylbenzenes boiling between 180 and 220 C. were distilled, under high vacuum, a 60 C. difference in temperature would occur between top and bottom of the still but about 3 to 6 C. difference would occur with steam distillation. When no temperature difference exists the concentration gradient must be controlled by some other variables or the distillate controller may be set to remove a certain portion of the feed.

Before plants are built using steam distillation, a good pilot plant should be operated using the feed proposed on the large unit. The equipment and controls should be designed with columns as models of the larger units. If good pilot plant data is not obtained, emulsions, foaming, low plate efficiencies and corrosion may make the large plant unsatisfactory. If the materials are allowed to separate on the plates so the vapors bubble through water instead of organic layer efficiencies may be very low.

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[2] Hayes, J. G., Hays, L. A., and Wood, H. S., *Chem. Eng. Prog.*, Vol. 45, No. 4, Pgs. 235-240, April, 1949.
[3] The Dow Chemical Company Files.

End of Part III. Part IV will appear in an early issue.

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SEE REVERE'S "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

[Who's Writing for *Petroleum Refiner*]

John W. Boatwright

Peter W. Sherwood

R. H. Parekh

Charles H. Fork

Boatwright Looks At 1967 Product Demand

"1967—What Will Be The Product Demand?" on page 79 is the forward-looking work of John W. Boatwright, general manager of the distribution economics department at Standard Oil Company (Indiana), Chicago.

Born in Lancaster, Kan. in 1903, Boatwright received his B.A. degree from William Jewell College, Liberty, Mo., his M.A. degree from American University, Washington, D. C., and his Ph.D. degree from Northwestern University, Evanston, Ill., where he was a member of the economics faculty in the College of Liberal Arts and the School of Commerce.

In 1932 he joined Indiana Standard as an economist in the sales research department after serving as an industrial examiner for the Federal Trade Commission for the year. He became head of the sales research department and, in 1947, was named to the position he now holds.

During World War II, Boatwright served on several PIWC committees. He is a member of the API Statistical Advisory Committee.

Consistent Sherwood Returns for No. 15

Peter W. Sherwood, who recently joined Ethyl Corporation, has a flair for consistency. He has consistently produced worthwhile papers in the field of chemical engineering, 80 at the last count, and has consistently had his name listed among PR authors. Fifteen times he has received a PR byline.

However, in his latest contribution, "Germany's Hydrogenation Industry Today," which begins on page 93, one slight inconsistency does appear: it was written from New York City, where he is now living. Formerly he has written from Pittsburgh, Pa., headquarters of Koppers Company and of Blaw-Knox Construction Company, with whom he has been previously associated.

A graduate of Columbia University, Sherwood lists his hobbies as golf, photography and music (with the accent on chamber music). He also displays a linquistic tendency, having a knowledge of French, German and Spanish.

The article in this issue is based on the author's observations which he made during visits to German hydrogenation plants last summer. This has been a renewal of acquaintances for him. Some five years ago he had seen these installations as a member of the U. S. Government's Technical Oil Mission.

Indian Discusses Hydrocarbon Stripping

One of the many Indians whose forefathers were not around when the pilgrims overparked at Plymouth Rock is R. H. Parekh, author of "Factors Affecting the Process Design and Operation of Multicomponent Hydrocarbon Stripping," on page 99.

The reason his ancestors weren't present is that they were with the rest of the Indians in India! Parekh, born and reared near Bombay, India, graduated from the University of Bombay, B.S. in chemistry, and scored the highest grades in his chemistry class. He is now a citizen of the U. S.

His advanced studies included postgraduate work at Massachusetts Institute of Technology, where he received his Masters degree in chemical engineering in 1939, and pre-doctorate work at the University of Michigan which was interrupted by World War II.

Now transplanted in Texas, he is a registered professional engineer for that state. Since 1941, except for one year he spent in the U. S. Army, he has been a member of the engineering staff of natural gas department of Magnolia Petroleum Company.

His "time-out" periods in the last few years have been given over to traveling through Europe, the Far and Middle East, winning the men's singles tennis title at the Magnolia Social Club of Dallas, Texas, for 1948 and 1949 and fixing the yard of his new home in Dallas.

C. H. Fork Continues Footings Discussion

Charles H. Fork, author of "Square Footings" which starts on page 145, is no stranger to the pages of PETROLEUM REFINER. In March of last year he contributed a discussion of circular and octagonal footings which proved very popular with readers.

A registered civil and structural engineer in California, Fork's occasional free time is devoted to mathematics, which he studies as a hobby. Presently with the Ralph M. Parsons Company as supervisory engineer, he has been working principally on sulfur recovery plants, refueling stations, a refinery plant and a large government project.

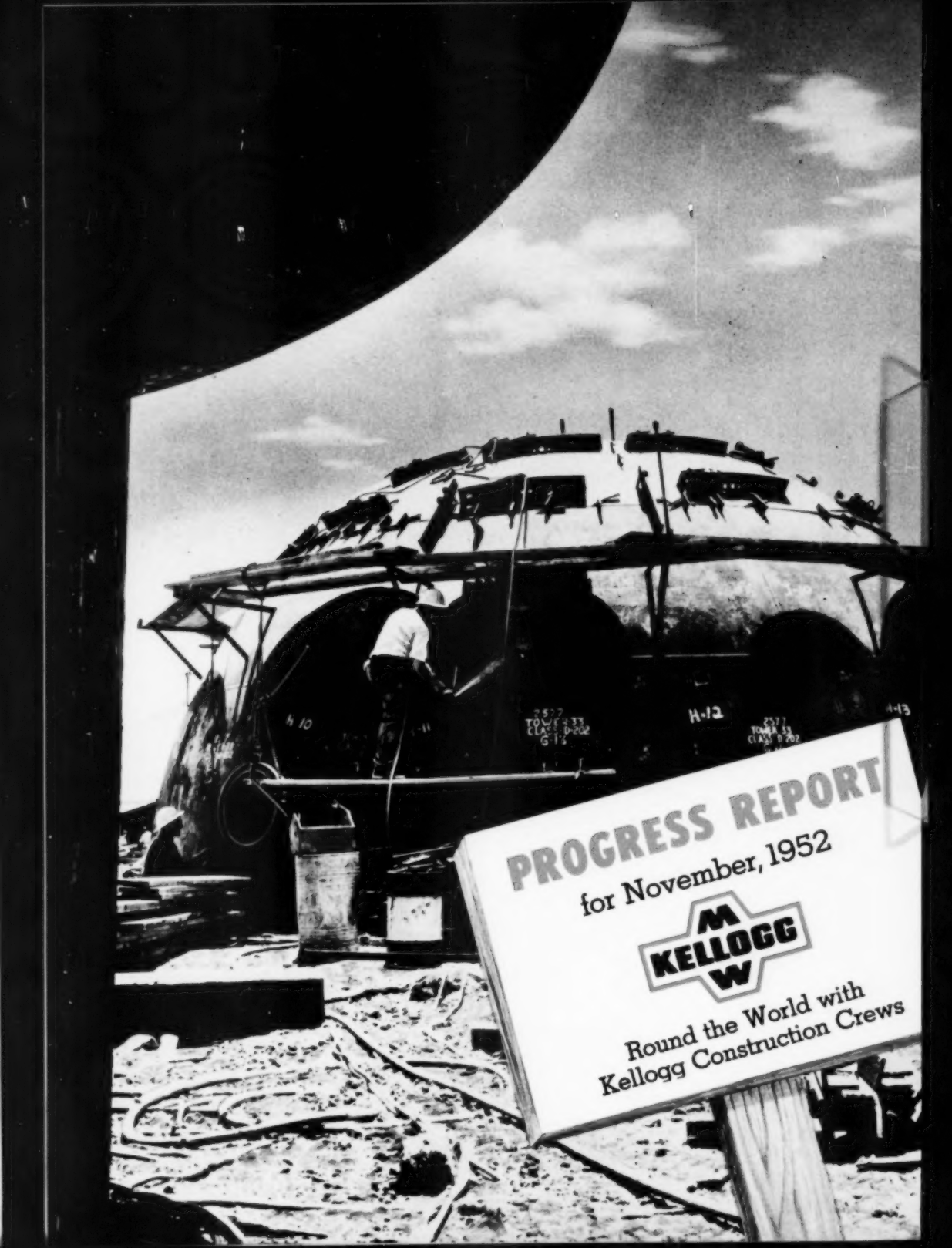
The math enthusiast grew up in northwestern Ohio, attending Ohio Northern University. In 1912 he received a degree in civil engineering. He continued engineering studies in advanced structural mechanics and mathematics, first at the University of Michigan and later at the University of California. In a book he compiled, "Structural Design Data," which is an extensive discussion on the deflection of beams, numerous useful equations were developed and graphed for practical use. He is a member of the Structural Engineers Association of Southern California.

Mekler Adds Again To Lengthening List

Every so often appears a man whose life's activities look as though they couldn't be crammed into three lives. Just such a fellow is L. A. Mekler, who, with Richard S. Fairall, compiled the readable facts and figures contained in "Evaluation of Radiant Heat Absorption Rates in Tubular Heaters," Part II of which starts on page 128. (Part I appeared in the June issue.)

Mekler's list of accomplishments, experiences, activities and memberships in organizations stacks up very favorably, at least in number, with all the words written about the Nixon fund.

In his own words, he was "born in


PROGRESS REPORT
for November, 1952
M
KELLOGG
W
Round the World with
Kellogg Construction Crews

PROGRESS REPORT for November,

First pictures of gasoline-from-coal synthesis plant in South Africa reveal considerable foundation work and structural steel already in place. The $50 million plant embodying Kellogg's Synthol process is the first commercial unit of its kind.

On the Gulf Coast, two three-stage pipe stills are well underway with completion scheduled for 1953. The units each comprise pre-fractionator, topping and vacuum towers. Main fractionator of one 60,000-BPD unit is shown in left foreground.

In the Southwest another important modernization program is beginning to take shape. Among the major units to be installed is an Orthoflow Fluid catalytic cracker. Here a crawler crane is employed in the erection of a pedestal for a guy derrick.

ROUND THE WORLD WITH KELLOGG CONSTRUCTION CREWS

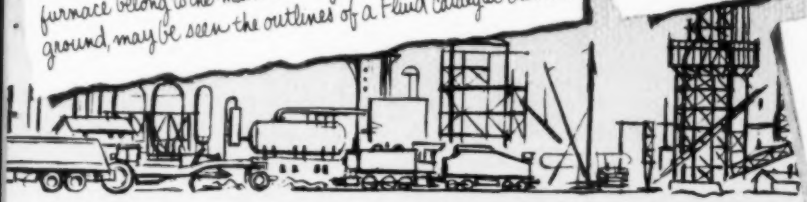
1952...continued...

(PHOTOS SHOW ACTUAL FIELD CONDITIONS AS OF OCTOBER 1, 1952)

Rated at approximately 63,000-BPD reactor throughput, a huge Fluid catalytic cracker is being erected in Philadelphia. This view shows recovery and underground water lines. Inset picture reveals progress on structural steel for main fractionator and catalyst storage drums.

In Argentina, a complete 28,300-BPD refinery is moving steadily along. Furnace stacks to the rear of the vertical furnace belong to the main crude furnaces. In the background, may be seen the outlines of a Fluid catalytic cracker.

One of nearly a score of chemical projects is in the pile driving stage on the West Coast. Pre-cast cement piles are being driven down to bed rock for this ammonia plant. One of its features will be Kellogg-designed reactors.



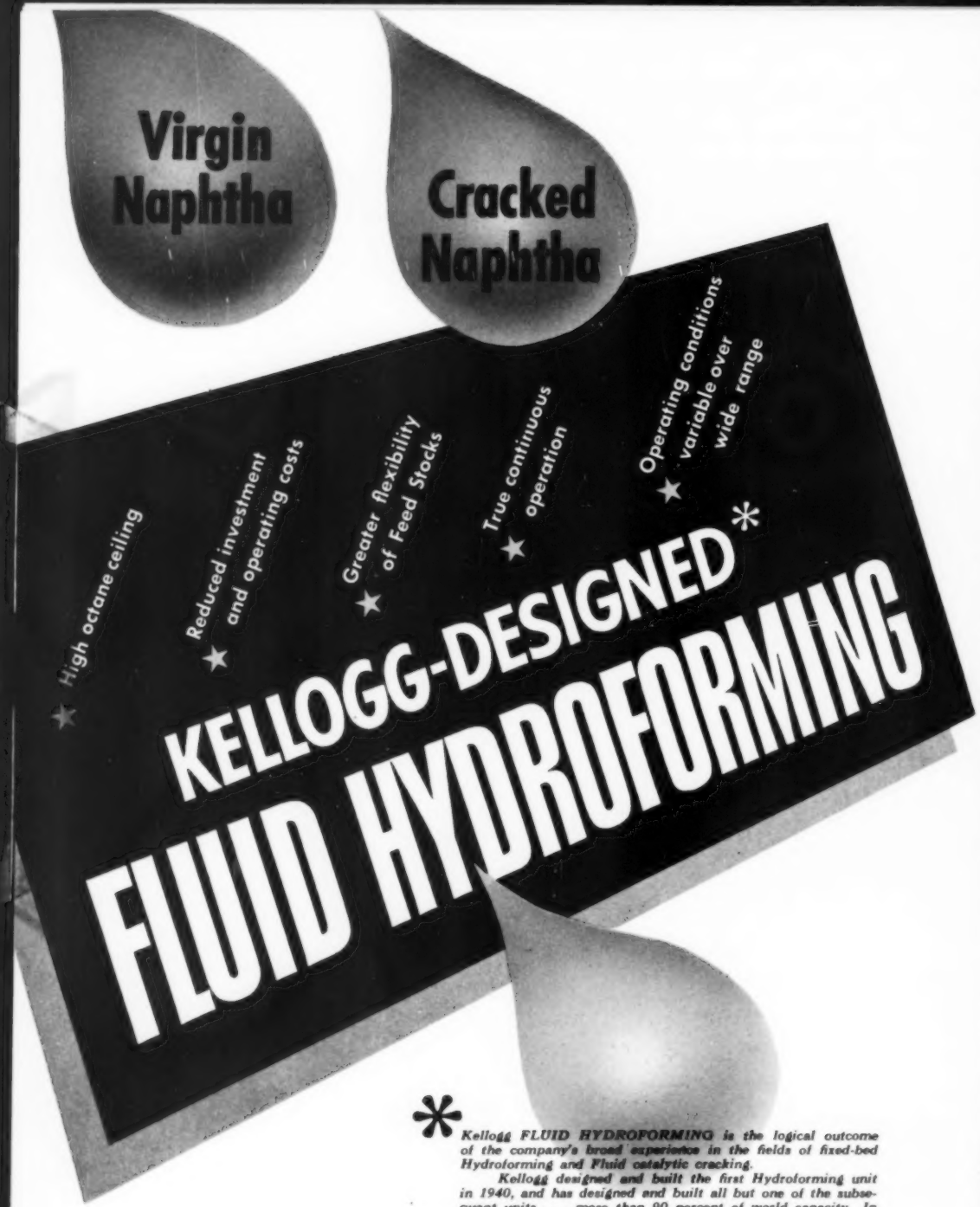
PROGRESS REPORT CONTINUED ON THIRD FOLLOWING PAGE . . .

IMPORTANT!

See next page for message about FLUID HYDROFORMING

M. W. KELLOGG

ROUND THE WORLD WITH KELLOGG CONSTRUCTION CREWS



* *Kellogg* ***FLUID HYDROFORMING*** *is the logical outcome of the company's broad experience in the fields of fixed-bed Hydroforming and Fluid catalytic cracking.*

Kellogg designed and built the first Hydroforming unit in 1940, and has designed and built all but one of the subsequent units . . . more than 90 percent of world capacity. In the field of Fluid catalytic cracking, Kellogg has engineered an annual capacity of better than 350 million barrels.

Comprehensive data on Fluid Hydroforming for both naphtha upgrading and aromatics production—from the company's own pilot plants and from all other authoritative sources—is available to Kellogg customers.

First to go on stream . . . will be this Fluid Hydroformer for a Gulf Coast refiner. It is scheduled for completion this month. Two others are now being engineered by Kellogg—one to be located in Louisiana and the other for the Mid West.

Each brings the advantages of efficient fluid catalyst techniques to the upgrading of naphthas . . . each is engineered to provide great flexibility in choice of operating conditions.

Catalyst level in the reactor can be varied over wide limits. The turbulent catalyst bed serves to improve catalyst-feed contact, and also functions as an important aid in temperature control. Steady, uninterrupted production of desired quality may be maintained continuously on any given feed stock, since fresh catalyst is introduced as necessary to maintain desired catalyst activity and selectivity.

Fluid Hydroforming provides higher octanes from low quality naphthas. And since it is a continuous, regenerative process, it is adjustable to a variety of feed stocks from hexanes (for benzene production) to kerosene, including virgin heavy naphthas, high-sulphur cracked naphthas and mixed virgin-and-cracked feed.

Fluid Hydroforming is not only more economical in operation but also requires a lower initial investment than comparable fixed-bed equipment. If you are considering expansion or renewal of naphtha processing facilities, a study of Fluid Hydroforming advantages will be rewarding.

Actual commercial operating data from this first plant will soon be available. But meanwhile, a Kellogg bulletin, "FLUID HYDROFORMING", gives detailed pilot plant data on performance of the process in handling virgin, coker and mixed naphthas from several different crudes. Copy will be mailed on request.

THE M. W. KELLOGG COMPANY

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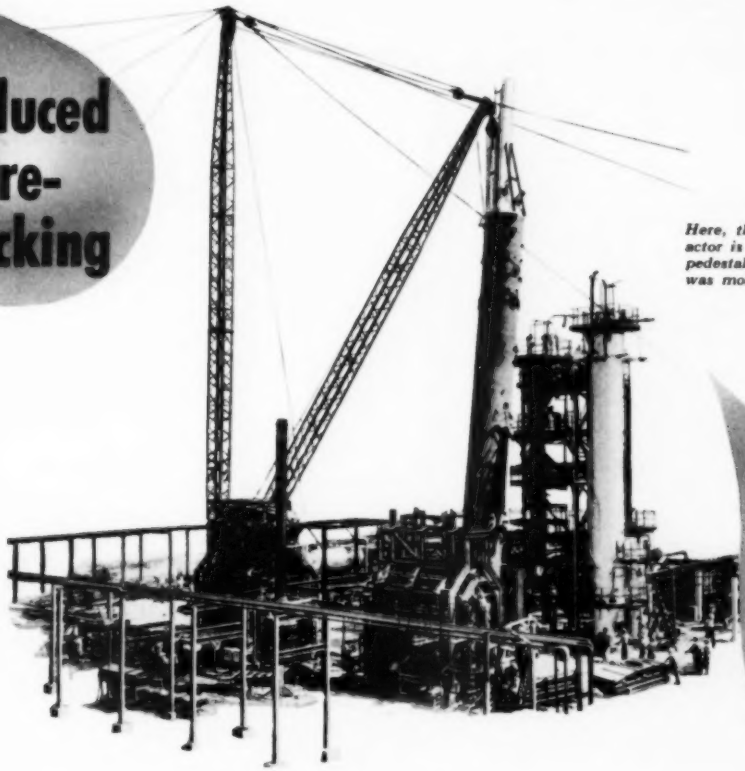
Reduced Pre-Cracking



Here, the Kellogg-designed reactor is lifted onto its concrete pedestal at a time when the unit was more than 80% complete.

High Octane Ceiling

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS

PROGRESS REPORT for November,

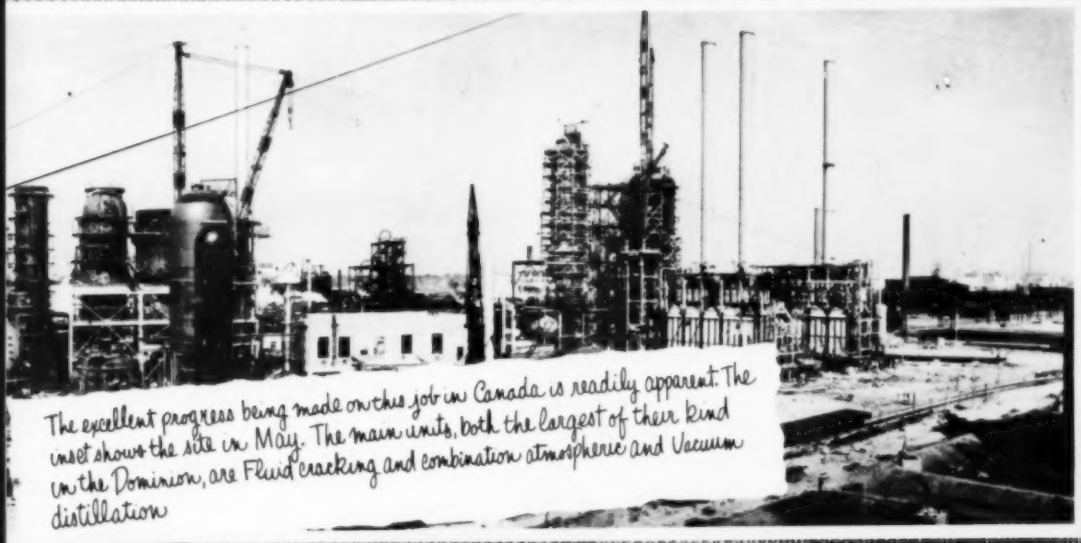
In Ohio, the pedestal for a large Orthoflow Fluid catalytic cracker has been poured. The job includes considerable other new equipment as well as modification of existing units.

Almost ready to go on stream is the world's first Fluid Hydroformer at Destrehan, Louisiana. Here the reactor is being hoisted into place. The pump house and control room are to the left of the fractionating towers. Completion is scheduled for this month.

ROUND THE WORLD WITH KELLOGG CONSTRUCTION CREWS

1952...continued...

(PHOTOS SHOW ACTUAL FIELD CONDITIONS AS OF OCTOBER 1, 1952)



The excellent progress being made on this job in Canada is readily apparent. The inset shows the site in May. The main units, both the largest of their kind in the Dominion, are Fluid cracking and combination atmospheric and Vacuum distillation

The British Isles are the scene of major activity in the erection of Kellogg-designed units. One of several different projects, this 17,500 vacuum flasher is now being finished in Scotland. The main furnace is shown to the right while in the foreground is the water cooler.

Shielded against the raw Wales' winds, welders continue work on the regenerator of a 10,000-BPD Fluid cracker for a British refiner. In other parts of the Isles, construction crews are erecting two additional catalytic crackers as well as other refining and chemical plants.

PROGRESS REPORT CONCLUDED ON NEXT PAGE

M. W. KELLOGG

ROUND THE WORLD WITH KELLOGG CONSTRUCTION CREWS

PROGRESS REPORT for November, 1952

KELLOGG

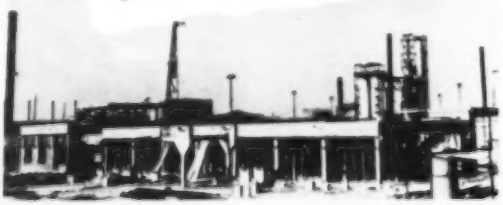
In Illinois most of the foundations are in place and steel work is going up for an octyl alcohol plant. The new unit will produce 10 million pounds annually.

This site was barely cleared in May. Now the world's first Phenol-from-Cumene plant is beginning to assume its finished appearance. The slender towers to the right are for purifying end products—phenol, acetone and methyl styrene.

In Italy, a thermal reformer (above) was just completed at press time. To improve the overall octane rating of the gasoline pool a catalytic polymerization unit is also under construction. Its partially-bricked control house is on the left. (see below)

OTHER MAJOR CONSTRUCTION PROJECTS IN WORK

Alkylation Plant — *U.S. East Coast*
Cat Poly Unit — *Scotland*
Complete Refineries — *One for Chile; one for Iraq; two for Brazil*
Deasphalting Units — *two, U.S. Southwest, England*
Decarbonizing Unit — *U.S. Southwest*
Desalting Unit — *U.S. East Coast*
Fat Splitting Unit — *Norway*
Fluid Hydroforming Units — *two, U.S. Gulf Coast, Midwest*
Olefin and Petrochemicals Plant — *Italy*
Orthoflow Crackers — *two, U.S. East Coast, Canada*
Phenol-from-Cumene Plant — *U.S. East Coast*
Phenol Treating Unit — *U.S. Southwest*
Phthalic Anhydride Plants — *two, England, Italy*
Solexol Decolorizing and Fractionating Unit — *Norway*



A KELLOGGRAM HAS JUST BEEN ISSUED WHICH FEATURES KELLOGG CONSTRUCTION OPERATIONS—IF YOU HAVEN'T RECEIVED YOUR COPY JUST DROP A LINE TO 225 BROADWAY, NEW YORK

ROUND THE WORLD WITH KELLOGG CONSTRUCTION CREWS

J. E. Blaylock, Jr. | E. D. Fox | Homer E. Rea, Jr. | D. N. Hanson

1894 during the parents' honeymoon trip." (The trip was 10,000 miles long and took two and one-half years.) Presently engaged primarily in consulting work, Mekler holds a B.A. degree from the University of Glasgow, a B.S. from the University of California and a Candidate of Commerce degree from Harbin, Manchuria.

His able assistant in this writing venture, though somewhat younger in years, has already begun carving out a big hunk of life for himself. Fairall, who received a B.S. in mechanical engineering from California Institute of Technology and a M.S. in the same field from Stanford, was research assistant on a Navy project on heat transfer while at Stanford.

Blaylock Holds Class On Wax Control Method

If you had to sum up J. E. Blaylock's activities since he graduated from Baylor University, Waco, Texas, in two words, you could do no better than "teaching" and "petroleum."

During the past ten years he has been employed as analytical chemist in the products control laboratory of the Magnolia Petroleum Company. Eight of these years have been spent in wax control work, a subject which prompted his interest in improvement of methods and equipment for oil content determination.

Prior to his association with Magnolia, Blaylock was an instructor at Lamar College, Beaumont, Texas, for one year. Before that he taught at Ranger Junior College, Ranger, Texas and Midland High School, Midland, Texas.

And now for the readers of REFINER he teaches "Here is a New Method for the Rapid and Accurate Determination of Oil Content of Paraffin and Microcrystalline Waxes," the informative "course" which starts on page 133.

The 39-year-old father of three children received his B.A. degree at Baylor in 1935, his M.A. degree in 1937. An amateur motion picture photographer, he finds ample opportunity to indulge in his favorite pastime with the aid of his three children as subjects.

Fox Gives New Ideas About Refinery Waste In Practical Article

During the past two years Edward D. Fox, author of "Processing Refinery Waste To Ammonium Sulfate," which starts on page 123, has been engaged entirely in process and project work connected with sulfur recovery plants. It was probably during that time that he collected the knowledge from which he drew to produce this informative article.

Presently project manager in the engineering and construction of sulfur recovery plants with The Fluor Corporation, Ltd., he received his bachelor's degree in chemical engineering from the University of Southern California in 1947 and is a Registered Professional Engineer in the State of California.

He spent six years as an engineer in plant layout and production for the Douglas Aircraft Corporation and one year as production supervisor in the electro-chemicals for the Western Electro-Chemical Company.

He joined Fluor in 1947 as a project engineer. His early assignments were concerned with process engineering for gasoline plants and various types of chemical plants.

Kohl Invites a Look At Radioisotope Uses

Jerome Kohl, head of the engineering department at Tracerlab, Inc., western division, is a fellow who knows what he wants. Since receiving a B.S. degree in Applied Chemistry, California Institute of Technology, he has followed a course of mounting success as an engineer.

His industrial experience is impressive. With Tide Water Associated Oil Company, he was assistant superintendent of the catalytic cracking plant at the Avon, Calif. refinery. He has also served as senior engineer with Tide Water. His work has included being project engineer in charge of design of a $7.5 million fluid catalytic cracking unit, project engineer in charge of a $2.5 million crude oil distillation unit, and many other top engineering assignments.

In this issue of REFINER, Kohl, who who has done several stints as an instructor, has another desire: he asks REFINER readers to "Check These Uses For Radioisotopes," beginning on page 117. Coming from a man who has served as consultant on numerous industrial applications of radioisotopes, it's a good suggestion.

Co-Authorship Stems From Campus Meeting

With their co-authorship of "Here's A Way To Make Fractionation Calculations For Existing Columns" which appears on page 139, Donald N. Hanson and Homer E. Rea, Jr., finally get together—verbally and geographically.

From a career of teaching at Wisconsin and Kansas State College and working as an engineer for Shell Development Company, Hanson wound up teaching at the University of California, Berkeley, Calif. Rea, meanwhile, had been occupied in a more southern area. For a while he was employed as chemical engineer for the Cottonseed Products Research Laboratory at College Station, Texas, but he soon moved west to become a graduate assistant at the University of California Radiation Laboratory while working on his Ph.D. At the University the two met and collaborated on the interesting article.

Hanson Gets Wisconsin Ph.D.

Hanson received his B.S. from the University of Illinois, his M.S. and Ph.D. from the University of Wisconsin. His main hobby is building a mountain cabin at Lake Tahoe but his interest in distillation column design and distillation processes leaves him little time to get to it.

After completing his work at the University of California this fall, Rea will join the Research and Development Group of the Union Oil Company of California. He is a member of Sigma Xi and the AIChE.

[What's Happening in the Industry]

PAD Sees Expanded Facilities For LPG Underground Storage

Facilities for underground storage of more than two million barrels of liquefied petroleum gas have been built in the past two years and additional projects now under way, or planned for construction, will bring the total underground storage capacity to nearly 5.9 million barrels by the end of 1953, according to a survey by Petroleum Administration for Defense.

In mid-1950, when underground storage facilities for LPG were first built, the PAD survey reported 26 producing companies and LPG distributors had planned or completed a total of 77 projects with an aggregate capacity of 5,862,500 barrels in 12 states. Present in use capacity totals 2,086,500 barrels of LPG underground storage. This total is expected to be increased by 3,034,000 barrels of capacity by the end of 1952 with the additional 742,000 barrels of storage capacity to be completed by the end of 1953.

About five-sixths of the underground storage capacity now planned or in use will be located in producing states of the Southwest, with over 3.1 million barrels in Texas. The smaller projects will be built chiefly in the Mid-West.

IPAA Chairman Predicts Total 1953 Oil Demand

The total domestic and export demand for all oils is expected to average 7,967,000 barrels a day in 1953, according to a forecast presented recently to the Independent Petroleum Association of America by H. B. Fell, chairman of IPAA's supply and demand committee. For the six months period from October 1, 1952 to March 31, 1953, the committee predicted a total demand averaging 8,339,000 barrels a day.

New Alkylate Expansion Being Planned by PAD

Establishment of a new alkylate expansion goal of 31,000 barrels a day in order to have a cushion for possible wartime demand is being considered by Petroleum Administration for Defense and the military. The proposed expansion will incorporate the unfilled balance of the current program, also the balance of 31,000 barrels a day, of which only about 8000 barrels a day have been contracted for.

PAD is presently intensifying efforts to win industry cooperation, either independently or under government contract whereby production is underwritten for five years. Of the 8000-barrel-a-day expansion already arranged, most of it is believed to have been on an independent basis.

Interest in Texas Plant Purchased by Maracaibo

Maracaibo Oil Exploration Corporation has purchased from E. J. Hudson, Houston, a 25 percent interest in a plant at Carthage, Texas, which produces gasoline, butane and propane from natural gas.

The plant processes about 8000 barrels a day of liquid products and is one of the largest of its type in the industry.

AIChE Main Speakers

The main speakers at the Seventh Annual South Texas A.I.Ch.E. Meeting were Sidney D. Kirkpatrick, left, vice president of McGraw-Hill Book Company and C. G. Kirkbride, right, president of Houdry Process Corporation. *Petroleum Refiner's* Editorial Director, Dr. John J. McKetta, who acted as the master of ceremonies at the banquet, is in the background. For further details see page 104.

Desiccant Discussion Sets NGAA Regional Meeting Pace

A fast-moving audience-participation program highlighted the Southern Regional Meeting of the Natural Gasoline Association of America held in Tyler, Texas on October 24.

Sustained interest in this part of the meeting was generated by informative talks by four authorities on dehydration, who formed a panel under the moderating of W. S. McAllister, Warren Petroleum. In ten-minute talks on desiccants were John Campbell, Black, Sivalls & Bryson; Clarence Glasgow, National Tank Company; Boyd F. Koepke, Aluminum Company of America; and E. Paul Wilkinson, Socony-Vacuum Oil Company. After the speeches, the panel answered questions asked by members of the audience, which numbered about 350.

The afternoon session of the NGAA meeting, which was held with the cooperation of the East Texas Natural Gasoline Men's Club, got off to another rousing start with a provocative talk by Dr. Arthur Smith, vice president of First National Bank, Dallas. Dr. Smith spoke on the present ills of the nation's economy and what it would take to return the U. S. to a "sound" economy.

Z. C. Ambrose, Southern Gas Association, served as chairman of the morning session and Albert H. Weil, United Gas Pipe Line Company, was chairman for the afternoon session.

Du Pont Survey Reveals Gasoline Octane Rise

The October, 1952 motor gasoline survey shows that the number of cities having higher octane gasolines of both premium and regular grades has increased since a July, 1952 survey.

The high of premium grade range remained the same from July to October but was found in Boston instead of in Baltimore, where it was in July. The low of premium grade range remained in El Paso, Texas.

The high of regular grade range moved up 0.4 from July to October, the survey shows. Boston took the honor, after sharing it with Cleveland last July. The low remained in El Paso.

ATAE Award of Merit Won by Compressed Air Institute

Compressed Air and Gas Institute, the trade association of manufacturers of industrial air and gas compressors and compressed-air-powered tools, has received American Trade Association Executives' 1952 Award of Merit for distinguished service. In the words of the citation, the Institute was presented the award "for its excellent services to its industry and especially for its education program centered on the schools of engineering throughout the U. S. and on the trade and technical press."

Cassaday Succeeds Judd as Lomita Gasoline President

L. V. Cassaday was recently elected president of the Lomita Gasoline Company of Long Beach, succeeding H. C.

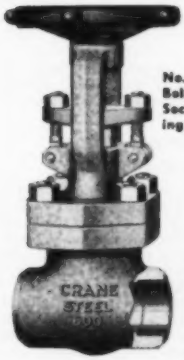
why CRANE 600-pound small steel gates are sure to meet your needs

You can't top these Crane Small Steel Gates for dependable performance on high pressure, high temperature lines . . . for ease of operation . . . for simplified maintenance. That's because they include design features normally found only in larger or more expensive valves.

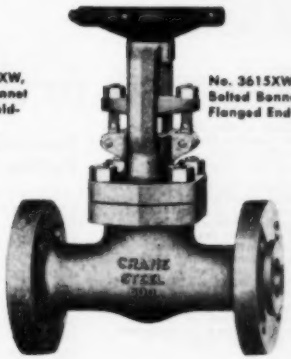
Then too, these Crane valves are available in a choice of types to meet your particular requirements. For example, with union or bolted bonnets; with screwed, flanged, or socket-welding ends; and in trim materials recommended for all common fluids.

GET NEW DESCRIPTIVE CIRCULAR AD-1881

For complete information—including prices—about these longer lasting, easier operating Crane Small Steel Gate Valves. Ask your Crane Representative for your copy, or write direct. No obligation.



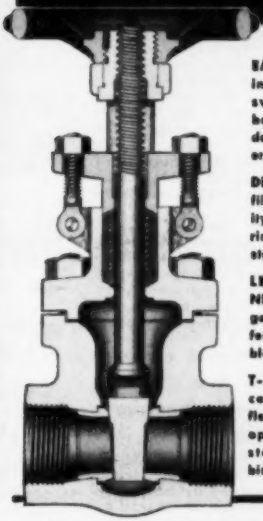
No. 3611XW, Bolted Bonnet Socket-Welding Ends



No. 3615XW, Bolted Bonnet Flanged Ends

UNION BONNET GATE. Screwed ends. Sizes: ¼ to 2-inch. Available in three different trim materials for a wide range of services. Also with socket welding ends

Easy to Operate... Easy to Service



EASY ACCESS to stuffing box assured by swinging gland eyebolts. Improved yoke design provides liberal working space.

DEEP STUFFING BOX filled with high quality asbestos packing rings maintains tight stem seal.

LEAKPROOF BONNET JOINT. Soft iron gasket in male and female joint cannot blow out.

T-HEAD DISC-STEM connection provides flexibility for smooth operation; prevents stem distortion or binding of parts.

Cross-section No. 3607XW, Bolted Bonnet Gate, Screwed

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Judd. Cassaday has been vice president and general manager of the Lomita company for many years and is widely known in Southern California.

The board of directors also elected J. E. Toussaint chairman of the board, and T. L. Taggart, vice chairman.

Standard (Indiana) Changes Industrial Relations Set-Up

Dr. William J. McGill, assistant general manager of manufacturing at Standard Oil Company (Indiana), has been appointed general manager of industrial and public relations. In this new position at the policy level in the Standard organization, Dr. McGill will supervise and co-ordinate the industrial relations and public relations departments. J. C. Ducommun will replace Dr. McGill in the manufacturing department.

Also from Standard has come the announcement of the appointments of F. Roe Weise as associate director of industrial relations, a new position, and E. W. Ahern and J. P. Nielsen as assistant directors of industrial relations of the company.

Weise has been assistant director of industrial relations; Ahern has been supervisor of the training section in the industrial relations department; and Nielsen has been superintendent of the industrial relations division at the company's Whiting, Ind. refinery.

Oil Industry Spends $765 For Each New Car Today

For every additional automobile that goes on the road today the oil industry has to buy $765 worth of producing, refining and distributing equipment, F. W. Ross, Standard Oil Company (Indiana) executive, recently told an Oil Progress Week luncheon meeting of the St. Paul Kiwanis Club.

Ross was explaining the "enormity of the oil industry's capital needs, based simply on the illustration of one additional car on the road."

"When you stop to consider," he said, "that in 1951 the number of cars in operation went up by about 2.4 million the total begins to reach staggering proportions. And I am not even mentioning additional trucks, buses, tractors, oil burners and other equipment dependent upon oil products—for which the oil industry must invest more productive capital."

Graduate Fellowship Program Expanded By Ethyl

An expansion of its graduate fellowship program for the coming school year has been announced by Ethyl Corporation. Ethyl awarded 21 grants for 1952 compared with 12 during the past year.

Begun 15 years ago, Ethyl's fellowship program is intended to assist by financial support and personal interest the professional training of research workers. Its object is to encourage university graduates to continue their professional training to an advanced degree. As in past years, the 1952-1953 fellowships are awarded in fields related to the petroleum, chemical and automotive industries.

Industrial Relation Veteran Appointed Sinclair Director

Millard E. Stone, for the past ten years director of industrial relations, bendix products division, Bendix Aviation Corporation, has been appointed as director of industrial relations for Sinclair Oil Corporation and subsidiaries.

Stone

Prior to his association with Bendix, Stone was director of personnel for the Electric Auto-Lite Company.

Presently chairman of the industry members of the Wage Stabilization Board, he was an industry member of the former Wage Stabilization Board and also served on the War Labor Board during World War II.

WHO'S MEETING WHERE

NOV. 1952	
17–18	Oil Industry TBA Group (Annual Meeting), The Park Plaza and Chase Hotels, St. Louis, Mo.
20–21	Western Region of the National Assn. of Corrosion Engineers (Second Annual Conference), Biltmore Hotel, Los Angeles.
30 to Dec. 5	American Society of Mechanical Engineers (Annual Meeting), Hotel Statler, New York.
DEC.	
1– 3	New Mexico Oil and Gas Assn. (Annual Meeting), Alvarado Hotel, Albuquerque, N. M.
1– 6	20th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.
7	Natural Gasoline Assn. of America, Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo, Texas.
7–10	AIChE, Annual, Cleveland, Hotels Cleveland and Carter.
9	National Petroleum Council (Fourth Quarterly Meeting), Department Auditorium, Washington, D.C.
JAN. 1953	
12–16	Society of Automotive Engineers (Annual Meeting and Engineering Display), Sheraton-Cadillac, Detroit.
19–23	American Inst. of Electrical Engineers (Winter General Meeting), Hotel Statler, New York.
FEB.	
1– 6	American Society for Testing Materials (Com. D-2 on Petroleum Products and Lubricants), Hotel Cleveland, Cleveland, Ohio.
5– 7	Missouri Petroleum Association, (Annual Convention), Hotel President, Kansas City, Kans.
16–18	American Petroleum Institute (Division of Marketing, Lubricating Committee Meeting), Sheraton-Cadillac, Detroit.
21	Natural Gasoline Assn. of America (Regional Meeting), Scharbauer Hotel, Midland, Texas.
MAR.	
2– 6	American Society for Testing Materials (Spring Meeting), Hotel Statler, Detroit.
8–11	American Inst. of Chemical Engineers, The Buena Vista, Biloxi, Miss.
15–19	American Chemical Society (125rd National Meeting), Hotels Biltmore and Statler, Los Angeles.
16–20	National Assn. of Corrosion Engineers, (1953 Conference and Exhibition), Hotel Sherman, Chicago.
25–27	Society of Automotive Engineers, (National Production Meeting), Hotel Statler, Cleveland, Ohio.

Mines Bureau to Study Synthetic Fuels Expansion

Defense Production Administration has revealed that it has asked the Bureau of Mines to establish expansion program goals for production of synthetic fuels from natural gas, shale and coal. The Bureau's synthetic fuels division has mapped a tentative program but it has not been approved within the agency.

The program covers annual goals through 1955. Because many synthetic fuels processes are still in experimental or testing stages, it was speculated that goals, even through 1955, would not be large.

In another development that indicates the rising interest in synthetic fuels, a National Security Resources Board official has disclosed that an appointment of a special group to study synthetic fuels possibilities will be suggested to President Truman by government agencies now drafting recommendations on the Paley Commission report.

The official said recommendations, to be made by the Resources Board after consultation with other governmental agencies, would go to the President around mid-November.

Vulcan Announces Process For Ethylene Oxide Production

A new fluidized bed process for the production on a commercial scale of ethylene oxide by direct oxidation of ethylene gas with air has been announced by Vulcan Engineering Division. The process is the result of joint endeavor by Vulcan and The Atlantic Refining Company.

The fluidized bed consists of the agitated suspension of a fine catalyst solid in a rapidly moving gas stream. This contrasts with fixed bed processes which employ a cafalyst in the form of large particles which are not being agitated and mixed by the gases. In the fluidized bed the agitation serves to keep a uniform temperature throughout the catalyst bed and prevents the formation of "hot spots." Thus the Atlantic-Vulcan process allows temperature control in the all-important reactor which in turn results in uniformly high yields of oxide under economic conditions of operation.

Sunray Oil Names Manley To New Executive Post

In connection with Sunray Oil Corporation's recent re-alignment of executive personnel, H. W. Manley takes over the responsibilities for the management of the company's manufacturing, sales and pipe line activities in California.

Manley has been a vice president in the company since March, 1951 and since May, 1952, a vice president and manager of the company's manufacturing sales and pipe line division.

API Research Project Marks 25th Year of Aid to Industry

One of the fundamental research projects which has done much to expand man's knowledge of oil marked its 25th anniversary at the recent American Petroleum Institute's meeting in Chicago.

Known as API Project No. 37, this study has successfully isolated 129 of the several thousand hydrocarbons pres-

The Mark of Sound Refinery Engineering

THIS is the mark of McKee engineering. To oil men all over the world it means sound process and plant design, thorough, efficient engineering and construction. It is backed by an organization with the integrity and experience, the scope and resources to undertake your refinery project and fulfill the promise that *McKee Engineering means assured results.*

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INTALOX*

The Unique

SADDLE PACKING

Gives You

- greater surface area
- more accessible surfaces
- greater free space

Which Means

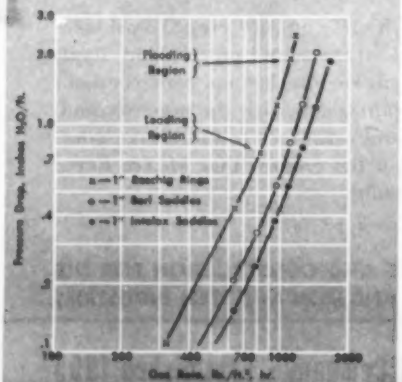
- lower pressure drop
- higher flooding limit
- higher flow capacities

TABLE ONE

Comparative Properties of Intalox

	Raschig Rings	Intalox	Berl Saddles
Nominal Size	1"	1"	1"
Approx. No./ft³	1350	2390	2200
Approx. Wt./ft³	40	39	45
Aver. Surface area ft²/ft³	58	78	76
% Free Gas Space	73	74	69

TABLE TWO



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"TOWER PACKINGS AND PACKED TOWER DESIGN"

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45PC

PROCESS EQUIPMENT DIVISION

ent in crude oil and has made available, mostly through synthetic methods, 200 pure samples of hydrocarbons which are now accepted as standards throughout the world.

Data developed by this project has been of great value to refiners and others because it enabled them to predict accurately how hydrocarbon mixtures would re-act under given circumstances.

Kellogg Appoints Multhaup To Department Manager Post

Appointment of Robert H. Multhaup as manager of its product engineering department has been announced by The M. W. Kellogg Company. In this capacity, he will be in charge of the design and engineering of all fabricated products.

Multhaup

Multhaup joined the company last year as project engineer on rocket design work. For eight years previously he was engaged in development work for the Elliott Company, where, as manager of the laboratory, he poineered in the design of gas turbines for marine and locomotive use.

New Hooker Subsidiary Plans Vancouver Plant

Hooker Chemicals, Limited, a British Columbia corporation which was recently formed as a subsidiary of Hooker Electrochemical Company, has acquired a plant site of approximately 60 acres on Burrard Inlet in the district of North Vancouver, B. C. The project carries rights to lease adjacent tidelands with about 1000 feet on the channel providing deep water transportation for raw material and finished products. The site will provide for the future manufacture of Hooker chemicals in this area.

No definite plans have been made as to date or details of construction of this plant. Substantial tonnages of chlorine and caustic soda for the growing British Columbia pulp and paper industry are now being supplied from Hooker's Tacoma, Wash. plant.

Davison Chemical Names Barrett As Research Head

Appointment of Dr. Wayne T. Barrett as manager of the research department of the research and development division of The Davison Chemical Corporation has been announced by that company. Dr. Barrett, who received his bachelor's and master's degree from the University of Pittsburgh, was formerly with the Phillips Petroleum Company and the Mellon Institute, where he was junior fellow in catalytic research. He joined Davison in 1950.

Two Personnel Changes Announced By Esso Standard

From Esso Standard Oil Company has come the announcement that Cecil Morgan, former director and vice president of the

P·A

GAS SCRUBBERS

• are stopping air pollution

• and recovering valuable materials

all over the country

More than five billion CFD! That's the installed capacity of P-A Venturi and Cyclonic Scrubbers now at work in twenty-six states and 9 foreign countries. These installations . . . all completed within the last four years . . . are proof of the success of Pease-Anthony methods of handling difficult gas scrubbing problems. • Bring your problem to Chemico. Take advantage of our experience in this field. Write to our P-A Sales Department for our specific suggestions. Ask for Bulletin M-102.

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More major oil fires have been put out with Pyrene Air Foam Equipment than with any other. Throughout the world—the Middle East, the Far East, Europe and South America—Pyrene* has long been *the* equipment for oil field and tank farm protection. Pyrene is available to you. Wherever *you* are—whatever *your* hazard—Pyrene is prepared to provide you with a built-in air foam system you can count on. For complete information, or the help of a Pyrene engineer, write us today.

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company, has resigned to become government relations counselor of the Standard Oil Company (New Jersey).

The company also disclosed the election of Bronce L. Ray, for more than 30 years associated with the company's marketing operations, as director of Esso Standard. Ray will continue as assistant general manager of marketing, a post he has held since 1948.

Five Staff Promotions Announced By Houdry

Houdry Process Corporation, Philadelphia, Pa., recently announced the following staff promotions: Henry D. Noll to director of engineering; A. Wesley Hoge to manager of engineering; Theodore A. Burtis to supervisor of process engineering; Josef W. Schall to director of development; and John B. Maerker to section chief of development.

Noll Hoge

National Grease Institute Wins Grand Award From ATAE

The National Lubrication Grease Institute has been presented with the Grand Award for outstanding service to its members and the general public. The presentation was made to the organization's executive secretary, Harry F. Bennett. This is the second time he has won the award.

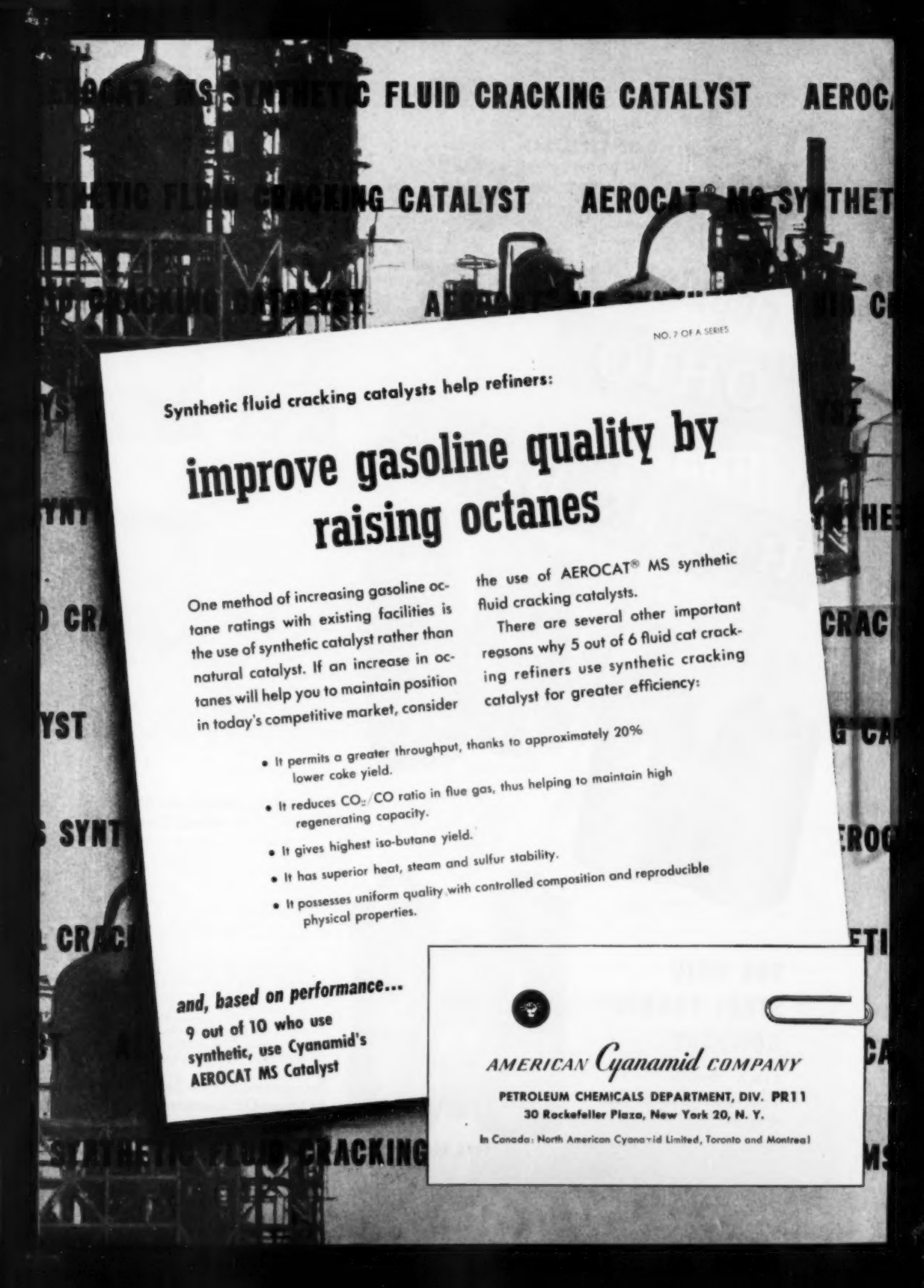
Known as the Grand Award for Distinguished Service, it is presented to the trade association judged by a Jury of Awards to have rendered the greatest service among all associations entering the contest.

The Awards Jury this year was comprised of: Secretary of Commerce Charles Sawyer, chairman of the jury; William J. Grede, president, National Association of Manufacturers; Dechard A. Hulcy, president, Chamber of Commerce of the U.S.; Edward H. Stromberg, Northwestern University; and Dr. Ray B. Westerfield, Yale University.

Consolidated Engineering Announces Staff Additions

Two additions to its engineering and research staffs have been announced by Consolidated Engineering Corporation.

Dr. Wilson S. Brubaker has been appointed senior research physicist and Dr. Paul Brock as engineering mathematician. Dr. Brubaker will work mainly in the field of mass spectroscopy, dealing with analyses of unknown mixtures of gases and liquids in the petroleum industry, chemical companies, atomic energy work and in other civilian and



NO. 7 OF A SERIES

Synthetic fluid cracking catalysts help refiners:

improve gasoline quality by raising octanes

One method of increasing gasoline octane ratings with existing facilities is the use of synthetic catalyst rather than natural catalyst. If an increase in octanes will help you to maintain position in today's competitive market, consider the use of AEROCAT® MS synthetic fluid cracking catalysts.

There are several other important reasons why 5 out of 6 fluid cat cracking refiners use synthetic cracking catalyst for greater efficiency:

- It permits a greater throughput, thanks to approximately 20% lower coke yield.
- It reduces CO_2/CO ratio in flue gas, thus helping to maintain high regenerating capacity.
- It gives highest iso-butane yield.
- It has superior heat, steam and sulfur stability.
- It possesses uniform quality with controlled composition and reproducible physical properties.

and, based on performance...

9 out of 10 who use synthetic, use Cyanamid's AEROCAT MS Catalyst

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3 most popular OHIO RETURN BENDS

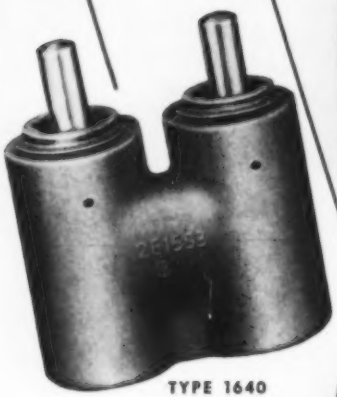
OHIO TYPE 1000: Adaptable to wide general use.

OHIO TYPE 1640: Ideal for high temperatures and pressures.

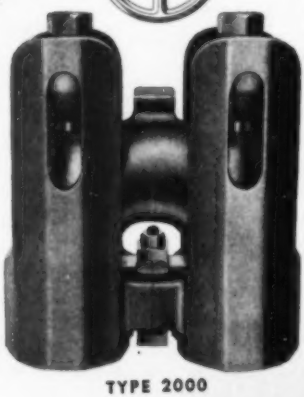
OHIO TYPE 2000: Designed for single tube replacement. The patented locking assembly eliminates the necessity for a rolling jig.

Descriptive pamphlets of any of the above designs will be mailed on request.

TYPE 1000



TYPE 1640



TYPE 2000

THE OHIO STEEL FOUNDRY COMPANY

LIMA, OHIO

PLANTS AT SPRINGFIELD AND LIMA, OHIO

military fields. Dr. Brock has been assigned to work with the company's computer group.

Vickers Named as President In Vickers Petroleum Shifts

In major executive shifts at Vickers Petroleum Company, Jack A. Vickers, Jr., son of the founder of the company, has assumed the presidency of that company. At the same time John S. Wertz, president for the past four years, took over the office of chairman of the board of directors, and James Beattie Smith, vice president and member of the board of directors since 1941, became executive vice president.

Vickers, Jr.

Wertz

Smith

Young Vickers has been with Vickers Petroleum, an independent, family-owned operation, since 1946, when he started in the scouting end of the business. Wertz has been with the company for the past 31 years, during which time he served as secretary and treasurer. Smith joined Vickers in 1937, after 11 years with Skelly Oil Company.

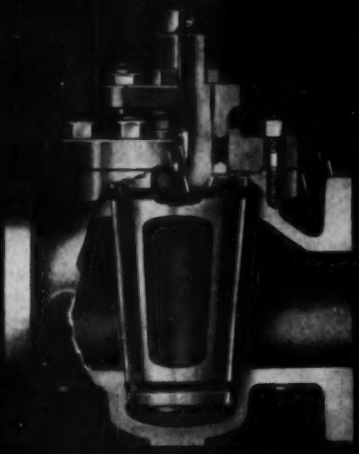
Five Ask Supreme Court for "Cartel" Proceedings Move

The Supreme Court has received appeals from five oil companies to order the transfer of the "international oil cartel" grand jury investigation from Washington to New York. The companies appealed chiefly because government employes predominate on the Washington panel and presentation of records in Washington would be unreasonably burdensome.

The Supreme Court has recessed until November 10, and it will probably be some time after that before any decision is made on the plea. The court can either refuse to hear the matter at all, thus ruling against the companies, or it can elect to consider the case and set a date for arguments. The Justice Department will probably file an answer soon.

Petrochemical Firm Set-Up As Union Oil Subsidiary

Brea Chemicals, Inc., has been formed by Union Oil Company of California as a wholly-owned subsidiary to develop,



LUBRICATED PLUG

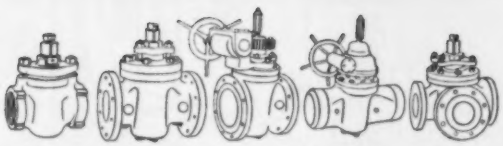
COMPLETE LINES OF LUBRICATED PLUG VALVES

Because of the wide range of services to which Lubricated Plug Valves can be adapted, they may be classed as "all-purpose" valves. Walworth manufactures complete lines of Lubricated Plug Valves in a variety of types and materials for working pressures up to 5,000 psi and for vacuum services. Sizes range from ½ to 30 inches. Write for descriptive literature.

Walworth also manufactures complete lines of gate, globe, angle, and check valves made of steel, bronze, iron, and special alloys.

Walworth valves, pipe fittings, and pipe wrenches total approximately 50,000 items and are sold through distributors all over the world.

Walworth engineers will be glad to help you with your problems. Call your local Walworth distributor, nearest Walworth sales office, or write to our General Offices, 60 East 42nd Street, New York 17, New York.



Illustrated in section is a Walworth No. 1700F Regular Gland Type, Wrench Operated, Steeliron, Lubricated Plug Valve. This particular line of valves has a working pressure rating of 200 psi at 150F or 125 psi at 450F. Sizes range from ½ to 8 inches. Other Walworth Lubricated Plug Valves include Single Gland and Ball Bearing types. They are available for a variety of working pressures.

For best results use Walworth Lubricants and Walworth High Pressure Lubricant Guns.

WALWORTH

Manufacturers since 1842

valves ... pipe fittings ... pipe wrenches

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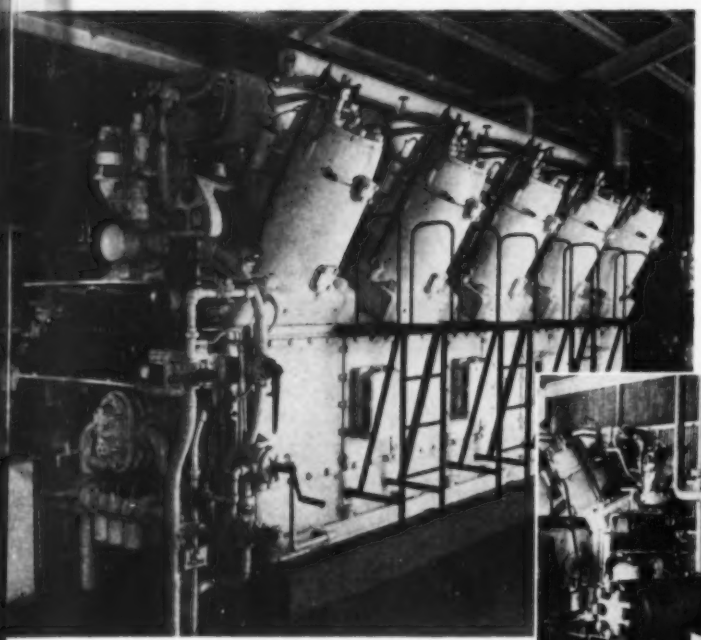
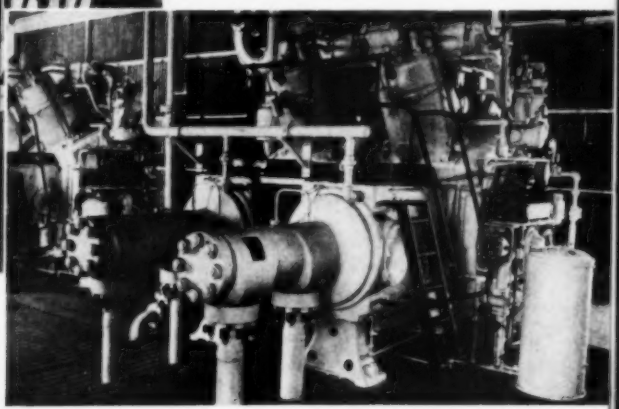
THEY COUNT ON THESE GMV's

for smooth operation in high-pressure ammonia service

Another Example of Efficient Power at Lower Cost



Crankdoor side of one of the GMV-10 process units, showing operating end with automatic control devices.

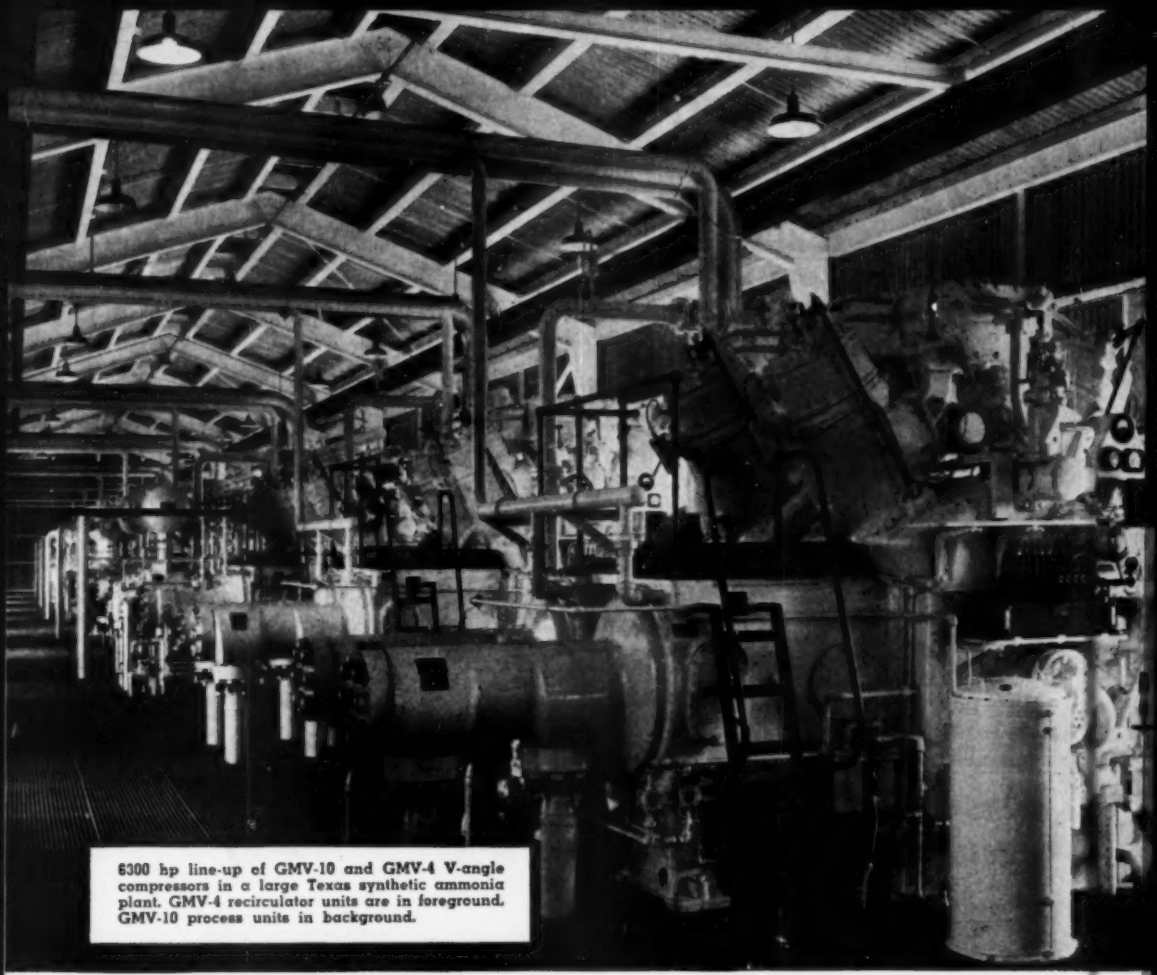


Close-up of high pressure compressor cylinders on one of the GMV-4 units in recirculator service—first application of its kind.

ANGLE

Compressors

New York Washington, D. C. Bradford, Pa. Parkersburg, W. Va.
San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.



6300 hp line-up of GMV-10 and GMV-4 V-angle compressors in a large Texas synthetic ammonia plant. GMV-4 recirculator units are in foreground. GMV-10 process units in background.

IN this Texas synthetic ammonia plant, these modern, reliable Cooper-Bessemer GMV's help in a big way to keep the process running smoothly. For example, GMV flexibility permits effective, dependable automatic control — set in this case to maintain constant suction pressure.

The compressor line-up consists of seven GMV's. Two are recirculator units — the *first* 2-cycle gas engine compressors to be used for such service. The other five are GMV-10 process units compressing a hydrogen-nitrogen mixture, through 5 stages, from 2 psig to 5300 psig.

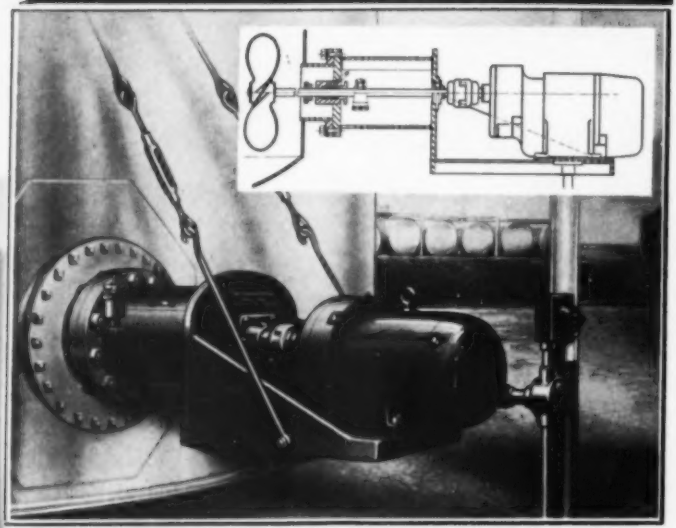
Here, in Texas, this same company operates *fifty-four additional* GMV's in 4 light hydrocarbon plants — plenty of experience to know that GMV quality and features pay off. In fact, Cooper-Bessemer V-angles are doing a real job in many a chemical and petrochemical plant . . . offering installation and operating economies seldom if ever matched.

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Tulsa Shreveport St. Louis Los Angeles Chicago Caracas, Venezuela

International's Type "NU" SIDE ENTERING MIXER



Wins fast acceptance! Users say it meets all requirements. Costs less to buy and Fully Guaranteed!

Here is a mixer that has no cast parts, being of all-welded construction, including the stuffing box,—nothing to break or get out of order. And due to its strong, simple construction it is replacing many complicated, and higher priced units. It is recommended for the most efficient, rapid and economical blending of gasoline, gasoline Ethyl mixing, lubricating and fuel oil blending as well as by-products. Indispensable in cycling operations and pipe line work—uniformity in charging stock—a natural for research, laboratory and pilot plants.

12 SIZES—FROM ½ TO 25 H. P.

This unit has two ball bearings, and a front single lantern bearing on the shaft, thus giving three bearing supports to the overhung propeller shaft. Quick access to the front ball bearing and the stuffing box gland is obtained by opening the hinged cover door on top. Repacked from outside without tank leakage . . achieved by the same positive arrangement as our other models.

If you have a mixing problem, we invite you to write us for Catalogs and any special Engineering information you may need. There is no obligation of course.

Look to **International**
FOR DEPENDABLE MIXING EQUIPMENT

INTERNATIONAL ENGINEERING, INC.

NEW YORK
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407 S. DEARBORN
WABASH 2-0733

manufacture and market chemicals from petroleum.

Homer Reed, formerly chief engineer for Union Oil, will be president of the new corporation. Temporary executive headquarters will be at Union's research center at Brea, Calif., with sales offices in Los Angeles.

Bureau of Mines Plugs Speedy Synthetic Production

Critical chemicals in short supply could be produced by coal hydrogenation process and marketed at competitive prices, Dr. W. C. Schroeder, head of the Bureau of Mines synthetic fuels development program recently told a meeting of the American Gas Association.

Schroeder re-emphasized the bureau's belief that domestic synthetic liquid fuels production from oil shale and coal should be started "as soon as possible, based on such considerations as effects of long war on petroleum supplies and on cost of conveying foreign oil in steel and manpower as well as money."

Elaborating on the chemical angle, he cited market potential for such as benzene, toluene, xylene, phenol and naphthalene.

The first logical step in the development of a synthetic fuels industry, he said, would be the construction and operation of pilot plants of about 10- and 15,000-barrel-a-day capacities. The bureau is now working on this step.

Accident Prevention Award Won By Shell Development

Shell Development Company, Emeryville, Calif., has received the Accident Prevention Award of the American Petroleum Institute for establishing a new high of 2.1 million man-hours worked without a disabling injury. A second certificate was awarded to the company's research division, which concurrently established a record of 1.4 million accident-free hours. The new records were reached this April. Previous high for the company was 1.2 million man-hours, established in 1951.

Fire-Damaged Shell Plant To Resume Operations

From Shell Oil Company has come the report that its 5,000,000-ton-a-year refinery at Cardon, Venezuela will come back into operation before long. It had been expected that the plant would be out of action for several months following a severe fire in the main power house.

The fire caused damage presently estimated at up to $560,000 and is believed to have been started by a short circuit when one of the main 7500-kilowatt generators which had been under repair was started.

The refinery, built since the war at a cost of about $168 million, is situated on Paraguana Peninsula.

Young America Learns of Oil

To inform young America of petroleum's part in building and maintaining the vitality of the nation, to counteract the widespread ignorance of oil's significance in the modern world, the Oil Industry Information Committee, public

name your refinery equipment needs

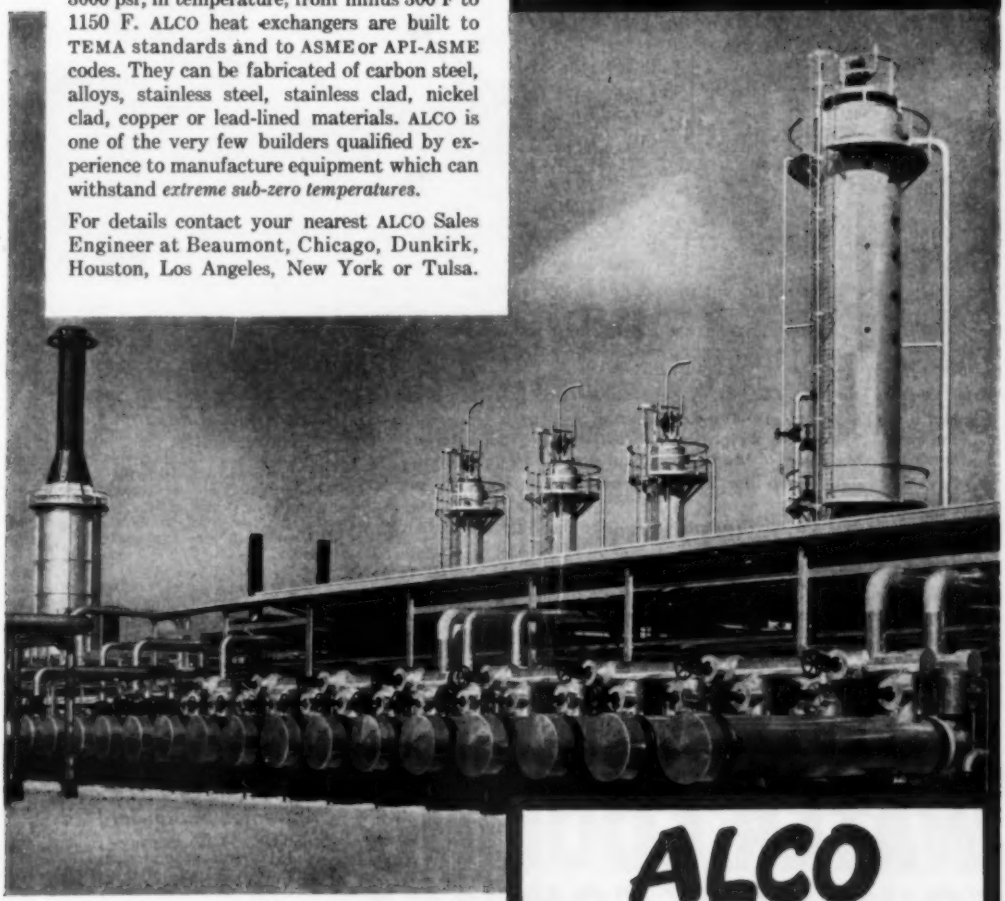
Custom engineering... that's the secret of ALCO's success at meeting virtually all of the refining industry's many equipment requirements.

Rugged ALCO products have been produced to cover an extremely wide range of requirements. Units vary in diameter from four inches to twelve feet; in weight, from 100 to 300,000 pounds; in pressure, from high vacuum to 3000 psi; in temperature, from minus 300 F to 1150 F. ALCO heat exchangers are built to TEMA standards and to ASME or API-ASME codes. They can be fabricated of carbon steel, alloys, stainless steel, stainless clad, nickel clad, copper or lead-lined materials. ALCO is one of the very few builders qualified by experience to manufacture equipment which can withstand *extreme sub-zero temperatures.*

For details contact your nearest ALCO Sales Engineer at Beaumont, Chicago, Dunkirk, Houston, Los Angeles, New York or Tulsa.

piping
pressure vessels
heat exchangers
product filters

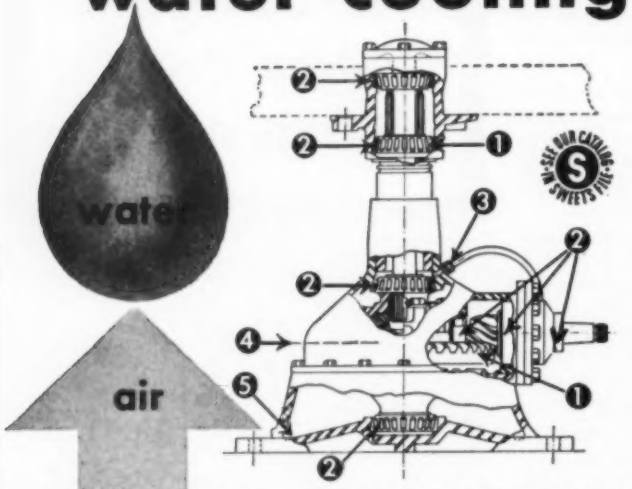
ALCO can meet them



ALCO

ALCO PRODUCTS DIVISION
AMERICAN LOCOMOTIVE COMPANY
Dunkirk, N. Y.

geared for better water cooling



One of the most vital parts of a water cooling tower is the gear reducer which drives the fan. Smooth, positive power must be transmitted quietly from motor to fan. Water Cooling Equipment Company are the original designers of semi-floating axle gear reducers for water cooling towers, the best type for this use.

Water Cooling Equipment Company gear reducers are the best because:

1. **Not a single pound of weight or thrust of the fan is transmitted to the gears. The entire weight and thrust — up to 1500 pounds — is carried by the lower of the two top bearings of the gear case.**
2. **Seven bearings keep the fan shaft and pinion shaft in perfect alignment.**
3. **Positive force-feed oil circulation provides the best lubrication for gears and bearings.**
4. **Large oil capacity assures cooling action on the gears and bearings.**
5. **The gear case is shaped so that any sludge formed in the oil is thrown out and down where it cannot recirculate over the gears and bearings.**

TOWERS OF STRENGTH WCEC

Semi-floating type WCEC gear reducers transmit more horsepower per pound of gear than any other design. All parts of WCEC gear reducers are standard automotive equipment available in moderate sized cities and towns.

Consider these many important facts when you discuss the purchase of a water cooling tower.

WATER COOLING EQUIPMENT COMPANY

MAIN OFFICE • 8601 New Hampshire Ave. • St. Louis 23, Mo.

***Fabricating Plants:* St. Louis, Mo. • Arcata, Calif. • Houston, Texas**

REPRESENTATIVES IN TWENTY-EIGHT PRINCIPAL CITIES

relations branch of API, has been busy with a program designed to promote understanding and appreciation of the industry.

First inaugurated less than two years ago, the program is employed in schools in 72 counties scattered across the U. S. Special booklets for students, guidebooks and handbooks for teachers, wall charts, and film strips, all prepared with emphasis on the industry, supplement approved textbooks.

Determining the acceptability of such a program by means of a poll, the OIIC took a long step toward insuring its success by enlisting oil men to push it at local levels. Later, a series of surveys will be made to measure the progress of the program.

Hainsworth Named As Advisor To Fluor Vice President

Fluor Corporation, Ltd., has announced the appointment of William R. Hainsworth as technical advisor to the executive vice president, J. Robert Fluor.

Hainsworth

Hainsworth was formerly research director and vice president in charge of engineering for Servel, Incorporated. He is at present serving as chairman of the general utilization committee of the A.G.A. Domestic Gas Research Committee, and chairman of the committee on approval requirements for gas refrigerators.

Union Oil President Sees Cheap Gasoline From Shale

It would cost $1.5 billion to do, but gasoline from Colorado oil shale could be sold in Los Angeles for 14.7 cents a gallon, against the current equivalent price of approximately 12 cents a gallon for gasoline from crude oil, at any time.

This estimate was presented to the annual meeting of the Texas Mid-Continent Oil and Gas Association recently by Reese H. Taylor, president of Union Oil Company of California. He said while he used Los Angeles as an example the figures would apply equally at Chicago or St. Louis.

The West Coast oil man said the problem of obtaining refined products from shale on a commercial basis is pretty well solved as far as the major engineering, mining and manufacturing phases go.

Section and Group Leaders Appointed by Standard Oil

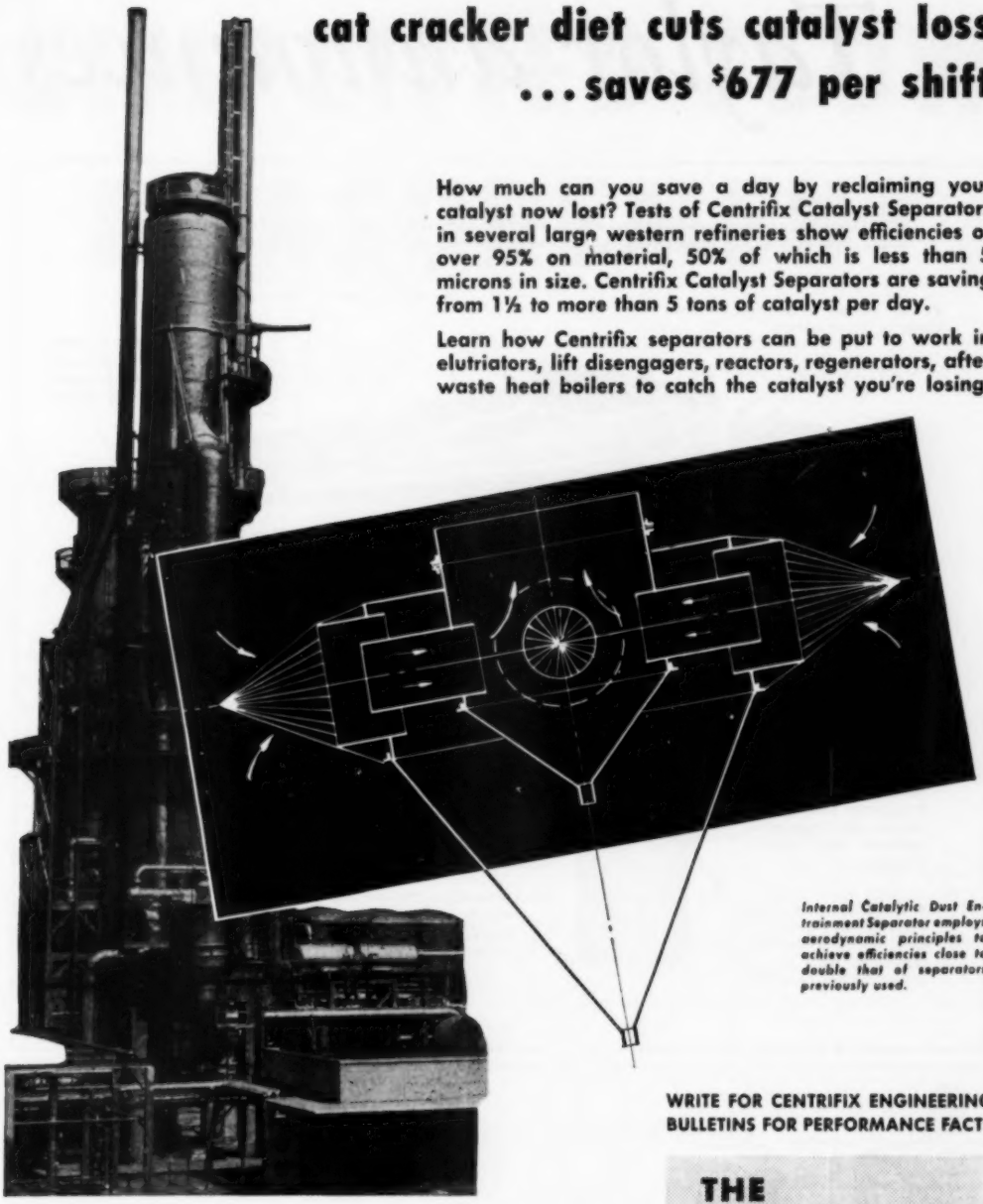
Standard Oil Company (Indiana) has made several appointments to section and group leaders in the research department at its Whiting, Ind., laboratory.

In the research divisions the appointments are: L. C. Brunstrum to section leader and H. J. Liehe to group leader, greases; A. W. Lindert, section leader, and R. S. Barnes, group leader, industrial lubricants; T. B. Tom, section

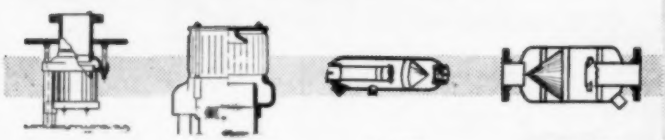
cat cracker diet cuts catalyst loss ...saves $677 per shift

How much can you save a day by reclaiming your catalyst now lost? Tests of Centrifix Catalyst Separators in several large western refineries show efficiencies of over 95% on material, 50% of which is less than 5 microns in size. Centrifix Catalyst Separators are saving from 1½ to more than 5 tons of catalyst per day.

Learn how Centrifix separators can be put to work in elutriators, lift disengagers, reactors, regenerators, after waste heat boilers to catch the catalyst you're losing.



Internal Catalytic Dust Entrainment Separator employs aerodynamic principles to achieve efficiencies close to double that of separators previously used.



FD UPFLOW FR DOWNFLOW RA LINE RW HD LINE

WRITE FOR CENTRIFIX ENGINEERING BULLETINS FOR PERFORMANCE FACTS

THE Centrifix CORPORATION
3608 PAYNE AVENUE
CLEVELAND 15, OHIO

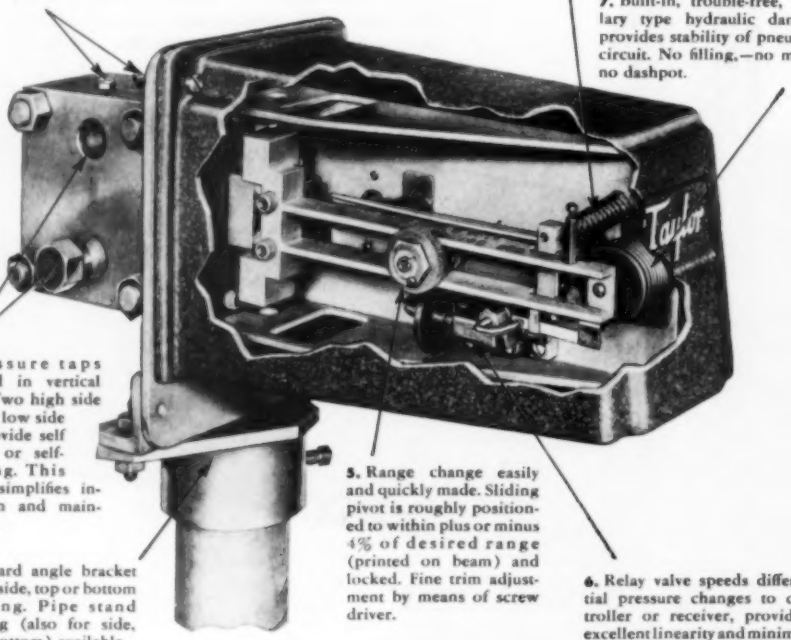
Taylor announces

1. Dry meter operates on force-balance principle. Diaphragm of Teflon coated glass cloth. Body working pressure rating 1500 psi. Available in either forged steel or type 430 stainless steel.

2. Vent screws to provide for total filling in liquid service.

8. Provision for adjustment of range suppression up to 100%.

7. Built-in, trouble-free, capillary type hydraulic damping provides stability of pneumatic circuit. No filling,—no mess—no dashpot.

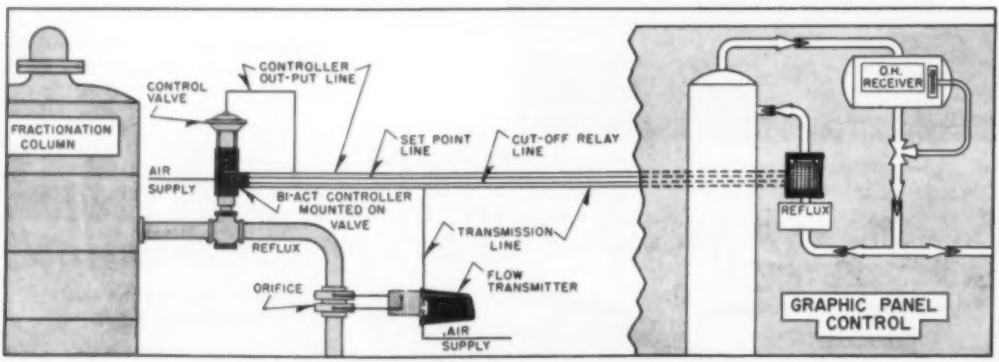


3. Pressure taps mounted in vertical plane. Two high side and two low side taps provide self venting or self-draining. This feature simplifies installation and maintenance.

4. Standard angle bracket permits side, top or bottom mounting. Pipe stand mounting (also for side, top or bottom) available.

5. Range change easily and quickly made. Sliding pivot is roughly positioned to within plus or minus 4% of desired range (printed on beam) and locked. Fine trim adjustment by means of screw driver.

6. Relay valve speeds differential pressure changes to controller or receiver, providing excellent linearity and minimum hysteresis.



SIMPLIFIED FLOW MEASUREMENT

With the NEW Taylor TRANSAIRE® Differential Pressure Transmitter

INEXPENSIVE AND SIMPLE TO INSTALL

1. Simplified piping because it can be close coupled to orifice flanges.
2. No leveling—mercuryless dry meter.
3. Side, top or bottom bracket mounting; available with 2″ pipe stand.
4. No seal pots required—negligible displacement because of force balance construction.
5. Light weight for easy handling; weighs only 23 lbs.
6. Vent screws for simple, solid filling.

ECONOMICAL—EASY TO MAINTAIN

7. Self draining or venting—no periodic manual venting or draining.
8. Mercuryless — flexible but tough Teflon coated glass fabric diaphragm.
9. Overrange protection to full body rating.
10. Purges, if required, can be installed to keep body swept clean.
11. Simple range change by sliding pivot—screw driver trim.

ACCURATE

12. Relay valve for linearity, minimum hysteresis, fast speed of response.
13. Pressure effect 0.2% / 100 psi. change.
14. Temperature effect 1.0% / 100°F. change.
15. Self draining and venting. No errors build up during operation.
16. Damped pneumatic circuit—stable air output even on vibrating pipe lines.

RUGGED AND DEPENDABLE

17. Body forged steel or type 430 Stainless Steel. Working pressure rating, 1500 psi.
18. Weather proof housing built for tough service and outdoor mounting.
19. Force balance construction—negligible motion—minimum possible wear.
20. Process sealing bellows 3-ply type 316 stainless steel.

ADAPTABLE

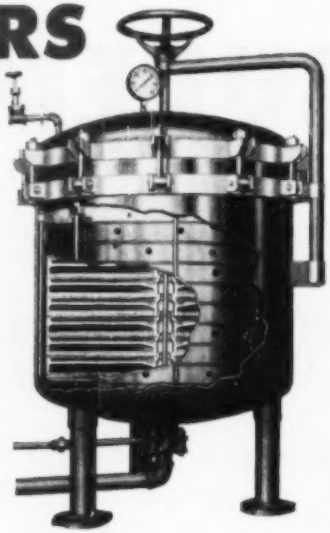
21. 100% suppression—continuously adjustable from 0 to 100%. Ideal for liquid level applications.
22. Ten-to-one rangeability in each of two forms: a. 20-200″ water b. 80-800″ water.

Find out more about this new flow and liquid level transmitter. Ask your Taylor Field Engineer, or write for **Bulletin 98226.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.*

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

SPARKLER
HORIZONTAL PLATE
FILTERS

Noted for High Quality, Consistently Uniform, Fine Sharp Filtration of Petroleum Products....



Many times Sparkler filters have been chosen by experienced filtration engineers in the petroleum field because of these specific features of superiority.

Sparkler filters deliver unusually high flow rates due to the horizontal plate construction that requires only a very thin precoat to produce fine sharp filtration right from the start. Less pressure is required with a thin precoat resulting in a filter cake of less density and high flow capacity. Intermittent operation or variation in pressures will not disturb the stability of the filter cake.

Any grade of filter paper, cloth, or screens, and any filter aid can be used with maximum efficiency because no pressure is required to hold the filter cake on the plate.

Frequently Sparkler filters are used in the petroleum industry with various grades of paper only without filter aid to perform a specific job that would be difficult or impossible with some other types of filters such as the removal of water from diesel lube oil or transformer oil.

A few typical applications of Sparkler Filters to the Petroleum and petro-chemical industries for the filtration of:

- Canned lubricating oil
- Methyl-Ethyl-ketone
- Polyisobutane
- Chlorinated hydro-carbons (carbon tet.)
- Aviation gasoline
- Jet engine fuel
- Hydraulic oil
- Gas engine & diesel lubricating oil (both continuous recirculation on the engine and batch-wise)
- Diesel fuel oil
- Cooling tower water
- Plant effluent water (to obviate stream and lake pollution)
- Removal of Raney nickel from alcohol streams
- Insecticides
- Caustics & acids
- Cottrell precipitator insulating oil (carbon black plants)

Sparkler horizontal plate filters are available in capacities from 30 to 30,000 G.P.H. depending on type of product filtered. Can be supplied in carbon steel, stainless steel, pure nickel, or monel, bronze, Hastelloy and Inconel. Rubber lined, brine or steam jacketed.

Sparkler representatives for personal engineering service are located in Dallas, Houston, San Francisco, and other principal cities. Western Branch, Los Angeles, California.

SPARKLER

Write Mr. Eric Anderson for your nearest Sparkler service representative.

MANUFACTURING COMPANY
MUNDELEIN, ILL.

Sparkler International, Ltd. Prinsengracht 876 Amsterdam, Holland

MAKERS OF INDUSTRIAL FILTERS FOR OVER A QUARTER OF A CENTURY

leader, and R. A. Hunt, group leader, light oils; R. A. Dinerstein, group leader, fractional distillation and hydrocarbon analysis; M. Den Herder, group leader, catalyst research; and J. W. Mohlman, group leader, information services.

In the technical service divisions M. Gordon, section leader, light and heavy oils finishing and asphalt manufacture; W. E. Stanley, group leader, light oils finishing; R. B. Selund, section leader, distillation, coking, heavy oils processes, and acid manufacture; W. E. McGinnity, group leader, heavy oils processes and acid manufacture; and E. R. Walter, section leader, and G. M. Goodman, group leader, economics.

Heat-From-Waste Catalyst Seen as Boon to Industry

A waste-burning catalyst which attracted national attention last spring by running an Allentown, Pa., plant on its own smells, has now been applied in the oil refining industry to make steam and electricity.

Ultimately expected to save American industry great savings in salvaged wastes and to eliminate air pollution at the same time, the catalyst has been proved successful by the Sun Oil Company. A partial installation, in a single petroleum-cracking unit at Sun's Marcus Hook, Pa., refinery, is saving the company $27,500 a year, enough to pay for itself and more. When complete the installation will return more than $80,000 yearly, according to Sun.

The new oxidation catalyst, basically of catalytic alumina and platinum alloy, was developed by Eugene J. Houdry, creator of the Houdry process of catalytic cracking of petroleum. This latter process was applied by Sun Oil for the first time anywhere in a large-scale operation at Marcus Hook in 1937.

Standard Oil (Indiana) Moves Livesay to New Post

P. C. Livesay, assistant general superintendent of the Whiting, Ind., refinery of Standard Oil Company (Indiana), has become manager of the projects, capital expenditures, and miscellaneous contracts division in the company's general office manufacturing department at Chicago.

Livesay joined Standard in 1937 as an engineer at Whiting. In 1943 he became foreman and in 1946 general foreman of the heavy oils division. He was appointed superintendent of the projects division in 1948 and assistant general superintendent of the refinery in 1950.

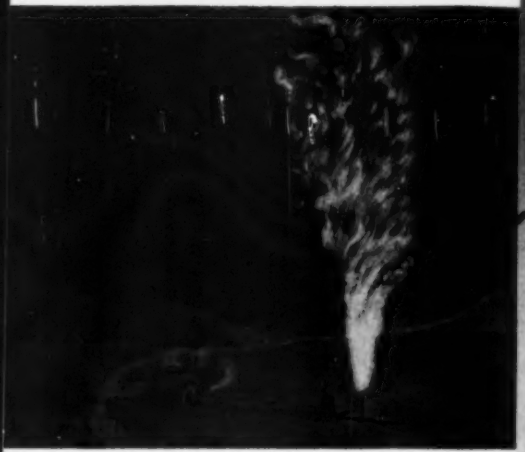
137 Kellogg Employes Have 25-Year Awards

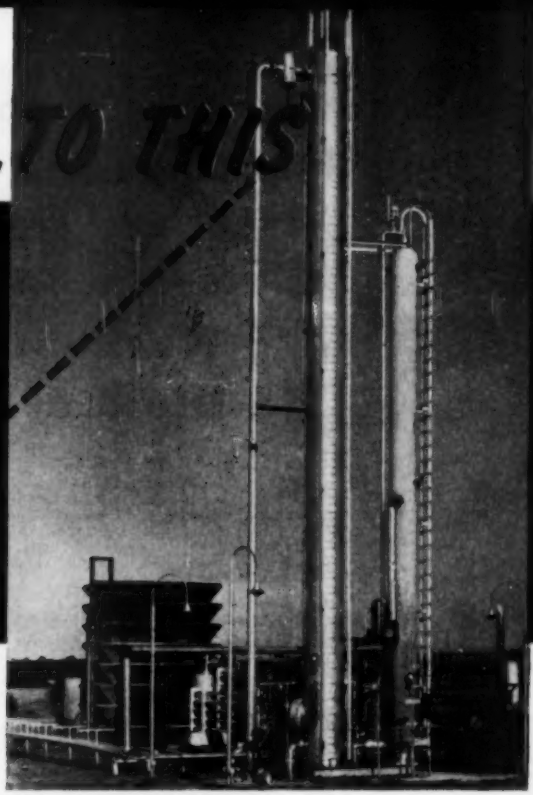
Fourteen employes of The M. W. Kellogg Company were recently given membership into the company's Quarter Century Club. Presentation of their awards at the club's annual dinner in New York brought the membership to 137 employes with 25 or more years of service.

Five Personnel Changes Announced by Phillips Chemical

Phillips Chemical Company has announced five personnel changes in its Bartlesville office. Edward Dolezal, chief

FROM THIS... TO THIS





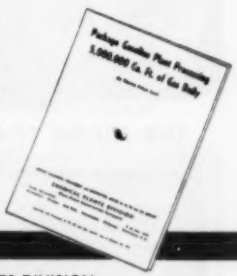
with a BLAW-KNOX PACKAGED GASOLINE PLANT

In self interest and sometimes in self defense it is advantageous to recover small amounts of casing-head or stock-tank vapors. For this specific purpose Chemical Plants Division of Blaw-Knox Construction Company offers a packaged plant featuring:

1. **The compactness and economy of "packaged" design and construction.**
2. **Skid mounting of the major plant units gives the plant better than 80% salvage value.**
3. **The elimination of steam for operating.**
4. **Relatively low labor requirements.**
5. **Gas operated instrumentation (no air required).**

Chemical Plants Division offers you the combined technical know-how of 300 engineers experienced in gasoline plant and refinery design. In this group are also a large number of experienced operational engineers, fully familiar with the problems involved in this type of plant. Our Southwest Division, located in Tulsa is specially fitted to serve the natural gasoline and petroleum industry. We invite your telephone call at Tulsa 5-8221, for more detailed information and will be glad to prepare proposals for your particular needs.

Advantages of this profitable plant are described in "Package Gasoline Plant Processing 5,000,000 cu. ft. of Gas Daily" by T. P. Cook, Chief Process Engineer of the Southwest Division of Blaw-Knox. Write for a copy.



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BLAW-KNOX CONSTRUCTION COMPANY
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Blaw-Knox Construction Co., Tulsa 1, Oklahoma
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For *Extra* Fast Easy Smooth Pipe Threading Choose

RIDGID

Work-Saver Die Stocks

JAM-PROOF 65R

Perfect threads on 1" to 2" pipe with 1 set of 4 high-speed steel dies—sets to pipe size in 10 seconds. Lead screw on barrel won't jam on workholder—drive plate automatically kicks out driving pawl. Self-centering workholder sets instantly!

4P GEARED THREADER

For 2½" to 4" pipe. Balanced loop handles—easy to lift 4P where you want it. Mistake-proof workholder sets to size before put on pipe—1 set screw. Safe enclosed gear. Practically no upkeep. Special 4P for conduit.

OOR RATCHET THREADER

For ⅛" to 2" pipe. Heads snap into ratchet ring from either side, won't fall out. Precision-cut alloy dies reverse for close-to-wall threads. 00R and 0R, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ⅛" to 2". Conduit dies, too.

EXTRA VALUE

RIDGID's are famous for efficient design, smooth performance, rugged durability. Every die stock factory tested. For top value for your money, buy RIDGID threaders from your Supply House.

THE RIDGE TOOL COMPANY • ELYRIA, OHIO

RIDGID

Work-Saver Pipe Tools

[What's Happening]

mechanical engineer, will be assigned to the newly created post of chief project coordinator. Austin Morgan, assistant chief mechanical engineer, will succeed Dolezal as chief mechanical engineer.

T. M. Hipp, presently on special assignment on an ammonia plant construction near Houston, will be transferred to Bartlesville and assigned to the newly created post of chief construction engineer.

M. W. Bennett, office manager, will be assigned to the newly created position of chief economics engineer, and M. W. Monk, assistant office manager, will succeed Bennett as office manager.

Changes In Personnel Announced By Imperial

The following changes in personnel have been announced by Imperial Oil Limited:

J. W. Jamieson, formerly assistant general manager of the manufacturing department, has been elected a director at the annual meeting. Dwight S. Simmons, general superintendent of Montreal East refinery, succeeds Jamieson. Charles Scrymgeour, superintendent of Imperial's Ioco refinery near Vancouver for the past four years, fills the Montreal post vacated by Simmons and is replaced at Ioco by E. K. Lewis, maritimer from Belmont, Nova Scotia who joined the company's imperoyal refinery in 1933. W. A. Murray, formerly assistant superintendent of Ioco, goes to Montreal as superintendent. A. G. Stewart, who joined the company's laboratory at Calgary in 1930, takes the post of superintendent at Winnipeg, the position vacated by Lewis. William A. Williams, superintendent at the Montreal plant for the past two years, becomes managing director of the Standard-Vacuum Oil Company's new refinery at Bombay, India.

Little, Inc., Opens Branch In St. Louis Under Kirkpatrick

Arthur D. Little, Inc., consulting industrial research and engineering firm of Cambridge, Mass., has opened a midwest office in St. Louis, Mo. The new branch will serve as a base for the organization's Technical Economic Survey in economics and market research in the mid west.

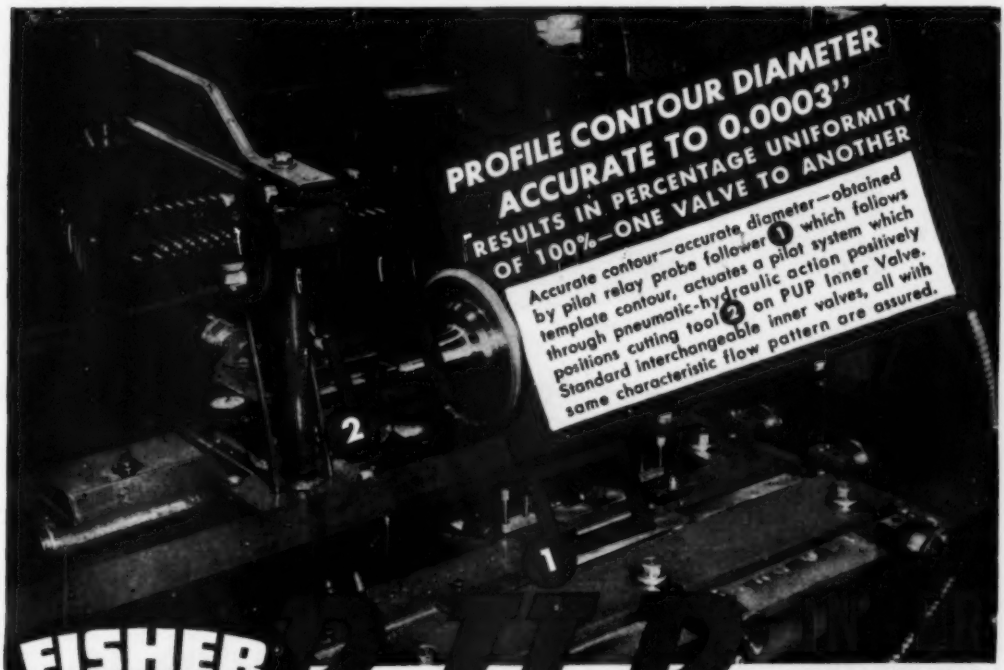
Chosen to head the new office was John R. Kirkpatrick, recently responsible for the industrial development activities of the company on behalf of the Puerto Rican Government.

Aries & Associates Set Up Branch Office In Detroit

The establishment of a Detroit branch office has been announced by R. S. Aries & Associates. R. A. Willinganz, a chemical engineer formerly with the Union Carbide and Carbon Corporation and the Chrysler Corporation, will head the new office and will be especially concerned with the technical economic work on new processes and products.

St. Maurice Chemicals Lays Cornerstone for New Plant

A cornerstone for a new formaldehyde and pentaerythritol plant has been laid


PROFILE CONTOUR DIAMETER
ACCURATE TO 0.0003"
RESULTS IN PERCENTAGE UNIFORMITY
OF 100%—ONE VALVE TO ANOTHER
Accurate contour—accurate diameter—obtained by pilot relay probe follower 1 which follows template contour, actuates a pilot system which through pneumatic-hydraulic action positively positions cutting tool 2 on PUP Inner Valve. Standard interchangeable inner valves, all with same characteristic flow pattern are assured.
2
1

FISHER PUP VALVES

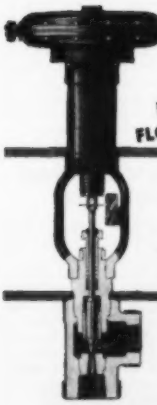
ROPORTIONAL NIFORM ERCENTAGE

PRECISION MANUFACTURED FOR ASSURED PERFORMANCE

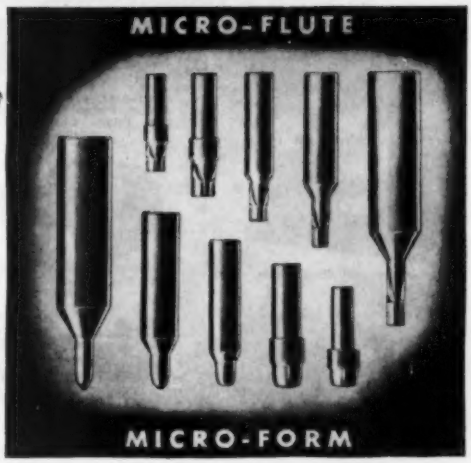
40 TO 1 RANGEABILITY

STAINLESS STEEL OR CAST STELLITE

EQUAL PERCENTAGE FLOW CHARACTERISTICS



Type 57T-DA direct acting diaphragm motor valve showing Micro-Form Pup in Fisher high pressure cast steel Design "D" angle body.



6 Years Old—Now Grand Champions

Excellent acceptance, phenomenal service and extremely satisfactory performance—that's the 6 year record of FISHER PUP INNER VALVES.

Available in two types, Micro-Flute and Micro-Form. Sizes ¼" to 1". Applicable to control valve sizes 1" to 2"

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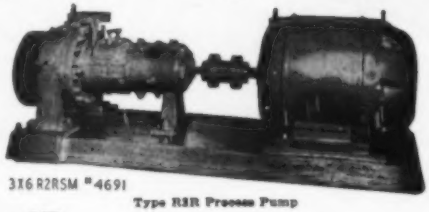
LEADS THE INDUSTRY IN RESEARCH

FOR BETTER PRESSURE CONTROL

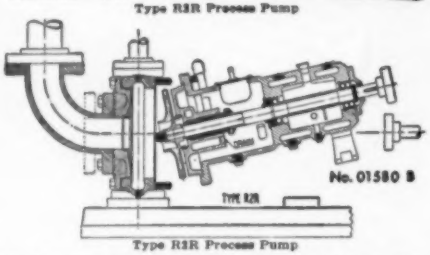
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



3X6 R2RSM "4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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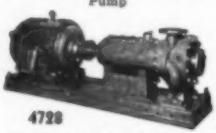
4000M
Close Coupled Centrifugal Pump

3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

4043 AA
Pedestal Mounted Centrifugal Pump

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



4728
Double Pedestal Bearing Centrifugal Pump

3554
Duplex Duplex Packed Piston Pattern Steam Pump, Side Pot Type

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at Vareenes, Quebec, by St. Maurice Chemicals, Ltd., of Montreal. The plant will have an annual capacity of 30 million pounds of formaldehyde and 3 million pounds of pentaerythritol.

Fewer Refineries Today, But Output Still High

There was a gain of 369,241 barrels a day in refining capacity during 1951, according to a survey by the Bureau of Mines. This brings the refining total to 7,332,885 barrels a day on January 1, 1952 and includes 171,519 barrels a day of shut-down capacity.

The Bureau found there were 350 refineries at the beginning of the year, seven less than a year before, but that average refinery capacity had increased 1445 barrels a day.

A free copy of the report may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13. The survey is called Information Circular 7646.

27,000 at Standard Oil Get Liberalized Employe Benefits

Standard Oil Company (Indiana) has liberalized employe benefit plans to increase benefits to its 27,000 employes while at the same time reducing the over-all cost to them.

The liberalized plans are said to increase annuity benefits for pre-1939 service for most employes and annuitants without cost to them, to permit early retirement with less sacrifice of annuity by the employe and to provide other benefits.

Wayne Keller Named To Executive Position

The National Research Corporation has appointed Wayne H. Keller as director of the chemistry department. Dr. Keller, a native of Kentucky, has a wide background of experience in the chemistry and research fields. Among other positions he has held, he was director of chemical metallurgy for the Manhattan district program at Iowa State College.

Dr. Keller's duties will include the direction of the large research program at National Research aimed at the economical reduction of metallic titanium.

Long-Time Corporate Counsel Retires from Cities Service

The retirement of Hayes McCoy, long-time corporate counsel for the Cities Service Oil Company (Del.), has been announced. McCoy joined Cities Service in 1916 and served on its legal staff at Bartlesville, Okla., until 1947, when he was named corporate counsel. He is a charter member of the General Mid-Continent Oil & Gas Association, has served almost 20 years as a member of the association's legal committee, the last 15 years as chairman.

Texas Company Names Borg

E. C. Borg has been appointed purchasing agent for the central division of The Texas Company, with headquar-

OUR 10th ANNIVERSARY OF BUILDING *BETTER* REFINERIES

Just 10 years ago, we received our first contract for remodeling the polymerization plant of the Ashland Oil & Refining Company of Ashland, Kentucky. This was followed by other contracts. This year, we have contracts for seven new cat crackers, as well as for other refinery construction. We are proud to state that we have had additional contracts from Ashland as well as nearly all refiners for whom we have done work.

We have just prepared a brochure information about our company work we are doing. Write for a copy on your company stationery, and one will be mailed you promptly.

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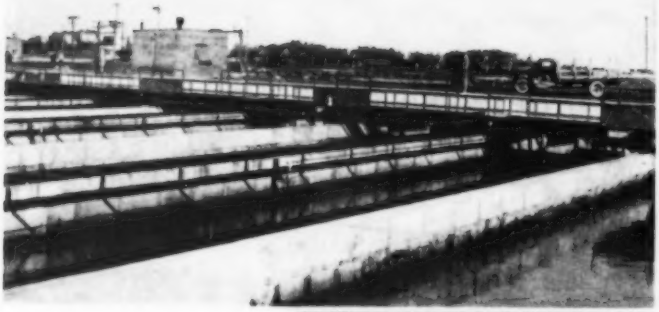
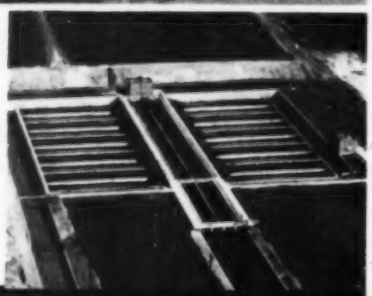
95% OF OIL RECOVERED FROM REFINERY WASTE WATER BY HARDINGE SEPARATORS



(Above) Part of the Hardinge installation of 21 rectangular clarifiers (oil separators) which remove about 300 barrels of heavy emulsion per day from 35,000 g.p.m. of refinery waste water at two Ohio refineries. The storage tanks for receiving the oil are shown in the background.



(Right) Aerial view shows primary clarifier in center with 10 secondary clarifiers on each side. The waste water enters through the culvert in the center and the effluent with 95% of oil removed flows out the canal at left.

300 Barrels Per Day Recovered

With increased demands for better methods of handling refinery waste water, systems using Hardinge Clarifiers as the primary separator have been gaining in popularity because of the high recovery of oil from the waste water. In this Ohio installation, the effluent from the Hardinge system contained 80 to 85% less oil than the previous system. Our engineers will provide you with the facts that you require.

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ters in Chicago. Philip Hauck will replace him as purchasing agent for the Pacific Coast division.

Born in Los Angeles and attending school there, Borg joined The Texas Company in 1929 as clerk in the purchasing department in Los Angeles. He was promoted to divisional purchasing agent in June, 1950.

Veteran Construction Man Promoted by Texas Natural

The Texas Natural Gasoline Corporation has announced the promotion of Clyde V. Quinn to the position of area superintendent. In his new capacity, Quinn will supervise all field operations, a responsibility he is qualified for by his almost 30 years of constructing and supervising operations of gasoline plants.

Quinn, who joined the Texas Natural Gasoline Corporation as construction and operating superintendent in 1948, recently supervised the expansion of the company's Benedum gasoline plant near Rankin, Texas.

Standard Oil of Texas Begins Houdriflow Operation

Houdry Process Corporation announced recently that an 11,500-barrel-a-day Houdriflow catalytic cracking unit has been put into operation at the El Paso, Texas, refinery of the Standard Oil Company of Texas. This Houdriflow installation constitutes part of the present expansion program with modern facilities announced earlier by the Standard Oil Company of Texas.

The new unit, begun last October, has been engineered and constructed by Catalytic Construction Company of Philadelphia, Pa.

Lakeside Refining Company Appoints Sandberg Manager

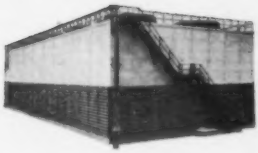
J. W. Sandberg, formerly with the Perco Division of Phillips Petroleum Company, is now refinery manager of the Lakeside Refining Company plant at Kalamazoo, Mich. After receiving a chemical engineering degree from McGill University in 1940, Sandberg spent two years with North Star Oil, Ltd. of Canada, and six years with Trinidad Leaseholds, Ltd. in the British West Indies. In 1948, he joined Phillips' Perco Division.

Jandacek Named to Post With Deep Rock Oil

George W. Jandacek has joined the staff of the research and development department of Deep Rock Oil Corporation. He will serve as a chemical engineer and will be stationed at Cushing, Okla. A graduate of Northwestern University, he was employed by a petroleum engineering company in Chicago before joining Deep Rock.

Arthur G. McKee Subsidiary Opens New Canadian Offices

Offices have been opened at 350 Bay Street, Toronto, Ontario by Arthur G. McKee & Company of Canada, Ltd., Canadian subsidiary of Arthur G. McKee & Company. Ralph A. Westervelt



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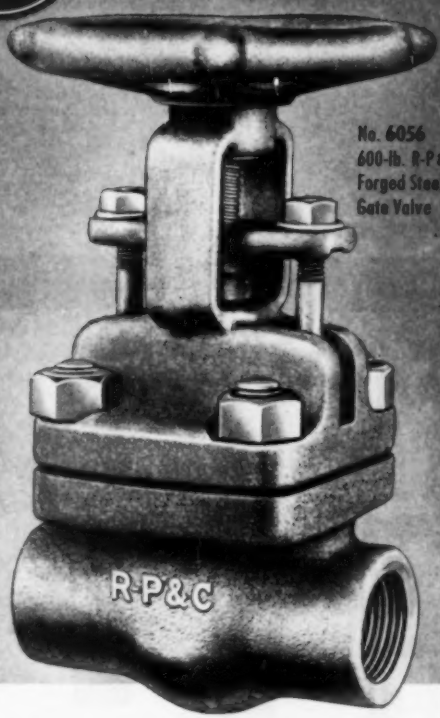

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R-P&C valves

has been appointed as vice president to direct the operations of the office. Westervelt is a native Canadian with 23 years of specialized experience in the field of engineering.

W. A. Kelly Elected Peabody Treasurer; Snider Retires

Judge William A. Kelly, head of the Stamford law firm of Cummings and Lockwood, was elected treasurer of Peabody Engineering Corporation at the last meeting of the board of directors. He will fill the vacancy created by the resignation of C. A. Snider who, as one of the founding directors of Peabody Engineering in 1920, is retiring as treasurer but remaining a director.

One Up and One to Go At Deep Rock Cushing Plant

Deep Rock Oil Corporation has reported two developments in the modernization of its Cushing, Okla., refinery. A new lubricating oil blending and packaging plant has been completed and is now in operation. Expected completion date of the new $2 million lubricating oil manufacturing plant now under construction is March, 1953.

Name Change Announced By Jefferies Engineering

Jefferies Engineering Company of Westfield, N. J., has changed its name to Engineering Corporation of America. The firm specializes in the designing and building of mechanical and process equipment for the chemical and petrochemical process industries.

Jessen To Teach At UT

Frank W. Jessen has become a visiting professor in Petroleum Engineering at the University of Texas for the year 1952-53. He is a member of AIME and AIChE.

Union Carbide Head Dies

Fred H. Haggerson, chairman of the board of Union Carbide and Carbon Corporation, died recently at the Roosevelt Hospital, New York, after a short illness. He was 68 years old.

Haggerson, who had been with Union Carbide over 33 years, became chairman of the board in 1951. He was made vice president of the corporation in 1938, a director in 1941, president and member of the executive committee in 1944.

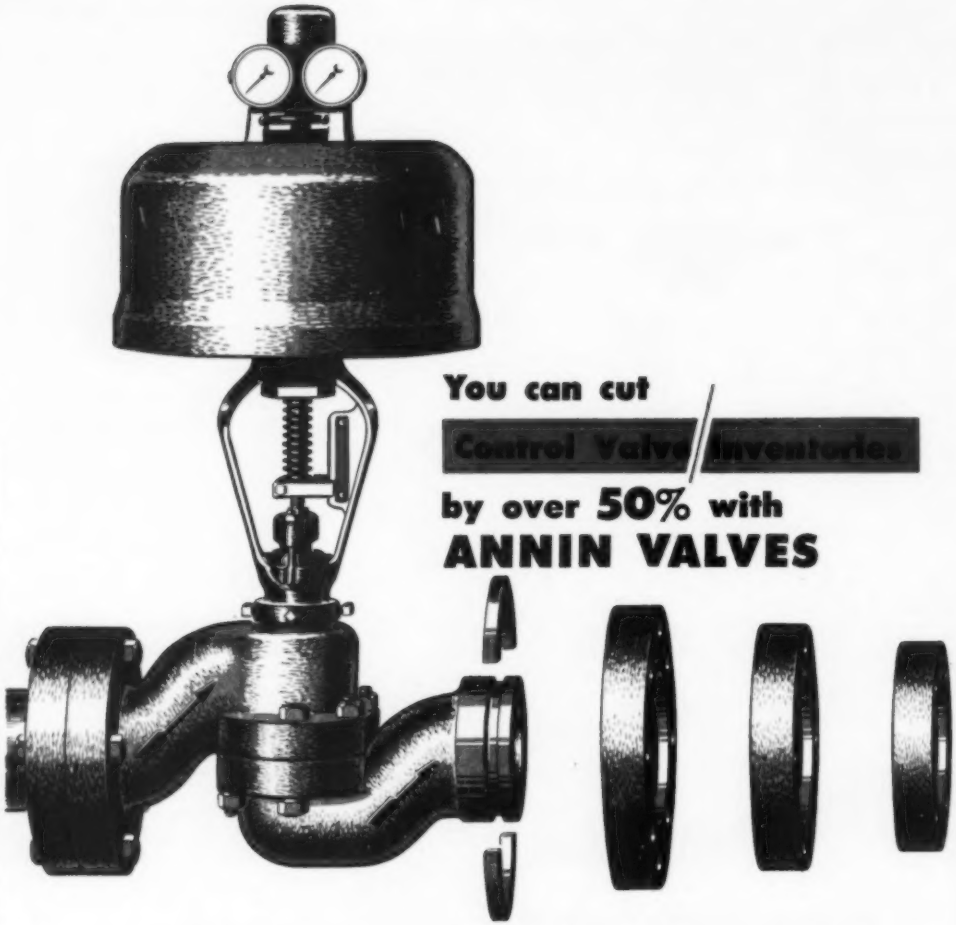
Former U. S. Steel Head Dies

Benjamin F. Harris, former president of United States Steel Corporation's National Tube Company, Oil Well Supply Company and Tubular Alloy Steel Corporation, died recently at West Penn Hospital, Pittsburgh. He was 66 years old.

Until 1943, Harris had been associated for more than 30 years with companies forming a part of U. S. Steel.

H. A. Mason Dies

H. A. Mason, assistant to the manager of laboratories with the General Petro-



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ANNIN CONTROL VALVES

THE ANNIN COMPANY 2200 Union Pacific Avenue, Los Angeles 23, Calif.

leum Corporation recently died. He was 58. He joined General Petroleum immediately after his graduation as a chemist.

Socony-Vacuum Head Receives Navy Award for War Services

During a special ceremony at the Pentagon, Secretary of the Navy Dan A. Kimball recently presented B. Brewster Jennings, president of Socony-Vacuum Oil Company, Inc., of New York, the Secretary of the Navy's Distinguished Public Service Award. This is the highest award the Navy may confer upon a civilian.

The citation, in part, notes Jennings' "important role in the successful supply of petroleum for the Allied Forces fighting on a worldwide front" while he served as deputy administrator for tanker operations, War Shipping Administration, during the first two years of World War II.

New Honolulu Refinery Sends Diesel Oil to Japan

Seventy-four thousand barrels of diesel oil, produced at the recently completed refinery of Pacific Refiners, Ltd., Honolulu, Hawaii, have been shipped to Japan. This refinery, designed by Fish Engineering Corporation, Houston, produces gas oil for the Honolulu Gas Company, butane for rural areas, road and roofing asphalt.

Shipment of the diesel oil was on the first postwar Japanese tanker to put in at Honolulu. Officials of Pacific Refiners "anticipate that there will be further foreign exports in the asphalt field, as well as a continuation of present exports of diesel to Japan and exports of toluene-xylene, and benzene to the mainland."

Union of California Shifts Reed to Top Executive Post

G. H. Hemmen, manager of the Oleum refinery on San Francisco Bay for Union Oil Company of California, has been appointed chief engineer of that company.

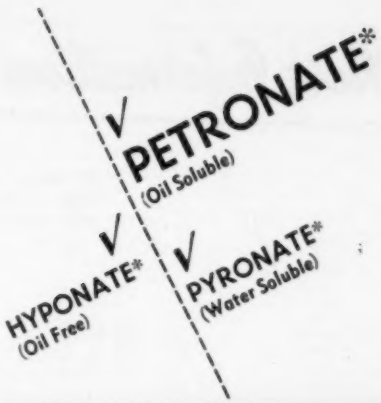
Hemmen will succeed Homer Reed, who has been elected president of Brea Chemicals, Inc.

Directors of Union Oil recently authorized formation of Brea Chemicals as a wholly owned subsidiary to develop, manufacture and market chemicals from petroleum.

Lenzen Named Vice President By Standard of California

Election of T. L. Lenzen as a vice president has been announced by Standard Oil Company of California. He joined Standard in 1928 after graduation and a year of graduate work in electrical engineering at Stanford University.

Lenzen has been manager of Standard's Eastern Hemisphere operation and has been closely affiliated with Middle East oil developments since 1938. He has spent considerable time as coordinator in the administration of Standard's interests in the affiliated producing, refining, transportation and marketing companies doing business in the Eastern Hemisphere.



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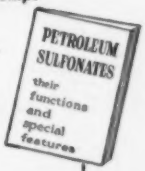

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(T4) Wyatt Metal & Boiler Works ..... IV Cover

Y

(T5) Yarnall-Waring Co. 222

The Handy Postcards → *Get Quick Action*

New Catalogs AND EQUIPMENT LITERATURE

For copies of the catalogs and new equipment literature listed, use one of the convenient Reader Service Postcards on this page. Just circle the number on the card corresponding to the number of the item in which you are interested.

Bubble Caps And Risers

Engineering data on 270 standard styles of bubble caps and risers for fractionating towers and stills are listed in a new catalog issued by The Pressed Steel Company. The 24-page booklet describes the processing equipment as well as tubes, welded tubing assemblies and manifolds which the company fabricates from present-day heat and corrosion-resistant sheet alloys. Also included are drawings for use in determining methods of bubble tray assembly.

Circle No. 1 on Postcard

Combustion Safeguards

Minneapolis-Honeywell Regulator Company's Bulletin 9603 contains data on combustion safeguards systems for industrial ovens, furnaces and other heat treating applications fired by multiple oil or gas burners.

Circle No. 2 on Postcard

Process Equipment

Blaw-Knox Company has published a new bulletin entitled "Process Equipment," which describes a variety of process equipment designed and manufactured by the company. Included in the 12-page brochure are such items as autoclaves, agitator assemblies and package pilot plants.

Circle No. 3 on Postcard

Company Information

The Ansul Chemical Company has published a booklet describing the company and its products and listing names of key personnel to be seen. Intended for distribution in the reception room to familiarize salesmen from other companies with Ansul, the publication extends a welcome to the visitor and offers a wide variety of information about the company.

Circle No. 4 on Postcard

Pressure Vessels

Taylor forge nozzles, welding necks and large diameter flanges are described in the new, illustrated catalog 501 published by Taylor Forge & Pipe Works. Included in the 44-page publication are charts, graphs and data covering standards of the Tubular Equipment Manufacturers Association. Taylor's forge publication, Modern Flange Design, is also incorporated as part of the catalog.

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A10	B10	C10	D10	E10	F10	G10	H10	J10	K10	L10	M10	N10	P10	Q10	R10	S10	T10

Name (Please Print)_____

Company_____ Position_____

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MAIL IT NOW . . . *CARD EXPIRES FEBRUARY 10, 1953

New Catalogs AND EQUIPMENT LITERATURE

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested

Heat Exchanger Tubes

Welded aluminum heat exchanger tubes with high resistance to corrosion have been offered by Aluminum Company of America. The new heat exchanger tubes are made by longitudinally butt welding Alclad 3S-H12 aluminum alloy sheet, rather than drawing seamless aluminum tubes.

A new booklet issued by Alcoa entitled "Alcoa Aluminum Heat Exchanger Tubes," describes the new tubes, which are available in two standard sizes, one-inch outside diameter with .049-inch and .065-inch wall thicknesses.

Circle No. 6 on Postcard

pH Control and Recording

Brown Instruments Division, Minneapolis-Honeywell Regulator Company, has issued a new four-page data sheet describing the Brown-Cambridge system for automatic recording and control of pH. Also included is a discussion of measuring system components adjustments for operation, as well as variations in recording and control systems for electric or pneumatic modes of control, and single or multi-point recording.

Circle No. 7 on Postcard

Vibration Meter

A new, 4-page bulletin describing the 1-110B vibration meter has been issued by the Consolidated Engineering Corporation. The vibration meter is described as giving direct readings of both linear and torsional velocity and displacement for rapid calculation of the vibrational traits of machines and structures. Five ranges of sensitivity allow the meter's full scale deflection to represent from 0.005 to 0.5 inch peak-to-peak displacement. The 1-110B has a four-stage, single-channel amplifier, stabilized by negative feedback to insure reliability over long periods of time.

Circle No. 8 on Postcard

Open Steel Welded Grating

A new type of open steel welded grating has been announced in The Klemp Metal Grating Corporation's new 24-page "Open Steel Grating and Stair Tread Catalog." The new publication, illustrated and with engineering data and charts, features the company's new Klemp-Krest, grating, which is said to give greater tensile strength and to make a stronger weld, thus effecting perfect distribution of the load in every direction over the area of each section.

Circle No. 9 on Postcard

Refractory Carbides

The Norton Company has announced publication of Norton Technical Bulletin No. 514 and No. 515, in which are described some of the company's materials such as refractory carbides, borides and nitrides.

The company has also announced a recent development in the field of highly refractory crystalline protective coatings. The development consists of adherent highly refractory coatings of oxides such as aluminum oxide or stabilized zirconia formed on the surface of graphite or metals such as steels and aluminum.

Circle No. 10 on Postcard

(More Literature Items on Pages 193, 195, 197, 199)

PETROLEUM REFINER Reader Service Postcard—November, 1952, Issue*

EDITORIAL ITEMS—Circle item numbers on which more information desired:

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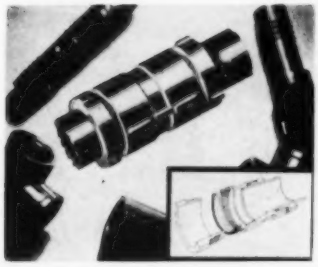
[What's New in Equipment]



Pipe, Compression Fittings

Carlon Products Corporation has announced the development and production of the improved Carlon "L" rigid plastic pipe and a new compression type coupling which incorporates a different design. Characteristics of the new pipe and fitting include increased resistance to burst, high tensile and flexural strengths, greater chemical resistance, ability to withstand sunlight, and increased life expectancy. It is recommended for processing on exhaust lines handling highly corrosive fumes, gases and vapors. It features an ultimate tensile strength of approximately 6000 pounds per square inch and an effective tensile for piping applications of 3600 pounds per square inch at room temperature. It is available in standard sizes from ½ to 2 inches.

Circle No. 11 on Postcard

Multi-Purpose Felt Tape

Spring-Felt pressure-sensitive tape with a duo-purpose adhesive which also provides for permanent attachment has been made available by Spring Packing Corporation.

It is claimed that Spring-Felt can't be permanently compressed, even under both heat and pressure, that it will not deteriorate and will always stay soft and pliable. Also said to seal against dust, air, fumes, moisture; to eliminate squeaks and rattles; to cushion glass and desk and bench equipment; and to resist flame, oil, fungus and mildew, it cuts cleanly and easily into shapes and gaskets.

Circle No. 12 on Postcard

Centrifugal Pumps

Allis-Chalmers Manufacturing Company's frame type centrifugal pumps, designed to handle pumping jobs requiring capacities up to 500 gpm. and heads as high as 135 feet, are described in a new bulletin released by the company.

Built for V-belt drive, the frame type pump can be mounted in a variety of positions and connected to any type of prime mover without difficult alignment problems. Head and capacity can be changed by simply altering sheave size on the V-belt drive.

Circle No. 13 on Postcard

Liquefied Gas Storage

Arthur D. Little, Inc., has issued a new catalog which summarizes the company's work with the production, handling and storage of liquefied gases, describes a high field strength electromagnet and reviews the company's prototype development service.

Circle No. 14 on Postcard

Steel Screw-Type Lever Gun

Lincoln Engineering Company's new high-pressure screw-type lever gun and fitting has been designed to dispense both bulk and cartridge lubricants in all kinds of weather. Constructed of heavy duty steel and equipped with a whip hose and coupler, it will develop approximately 10,000 psi. of pressure.

The job of removing the "lubricant screw" each time a lubricated valve is serviced is eliminated through the use of the new gun. Complete information is available upon request.

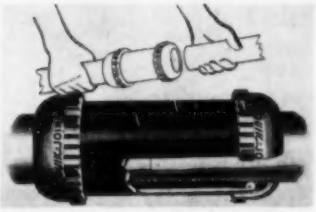
Circle No. 15 on Postcard

Flexible Plastic Pipe

Tennessee Eastman Company has developed a plastic pipe which has light weight, toughness and a high resistance to paraffin collection and wax accumulation. Because of these factors, Tenite Butyrate plastic pipe serves well as a surface flow line between an oil well and a tank battery header and in other systems where flexibility and resistance to corrosion are required.

A permanent welded connection is made between lengths of the pipe by means of a solvent cement and a slip-sleeve coupling. A paintbrush is used for applying the solvent cement.

Circle No. 16 on Postcard



Assembled Pipe Coupling

A factory assembled pipe coupling which can be installed in any piping system in less than 60 seconds has been announced by Quik-Joint Manufacturing Company. No thread cutting is required. Pipes to be connected are inserted into the ends of Quik-Joint coupling body and the lock nuts wrenched to desired tightness. The result is a tightly sealed but flexible joint capable of withstanding working pressures up to 2000 psi. No castings are used; the body is of pressure-tested pipe steel having a greater wall thickness than the pipe to be joined. Lock nuts and gasket retainers are drawn from cold rolled steel. The compression rubber gasket comes in a number of formulae depending upon the desired application. Quik-Joint is available in sizes from ½ to 1½-inches I.P.S. as straight coupling, 90 degree and 45 degree ells, welded and threaded adapters. Special lengths and bends to specification are also available. A descriptive brochure will be sent on request.

Circle No. 17 on Postcard

Pipe Insulation

It is claimed that two new corrosion resistant tapes manufactured specifically for pipe-wrapping by Minnesota Mining and Manufacturing Company combine the anti-corrosion qualities of poly-vinyl chloride and the ease of application of a pressure-sensitive tape.

Called "Scotchrap" pipe insulation No. 50 and 51, they are packaged and sold by the square, the standard unit in the pipe-coating field.

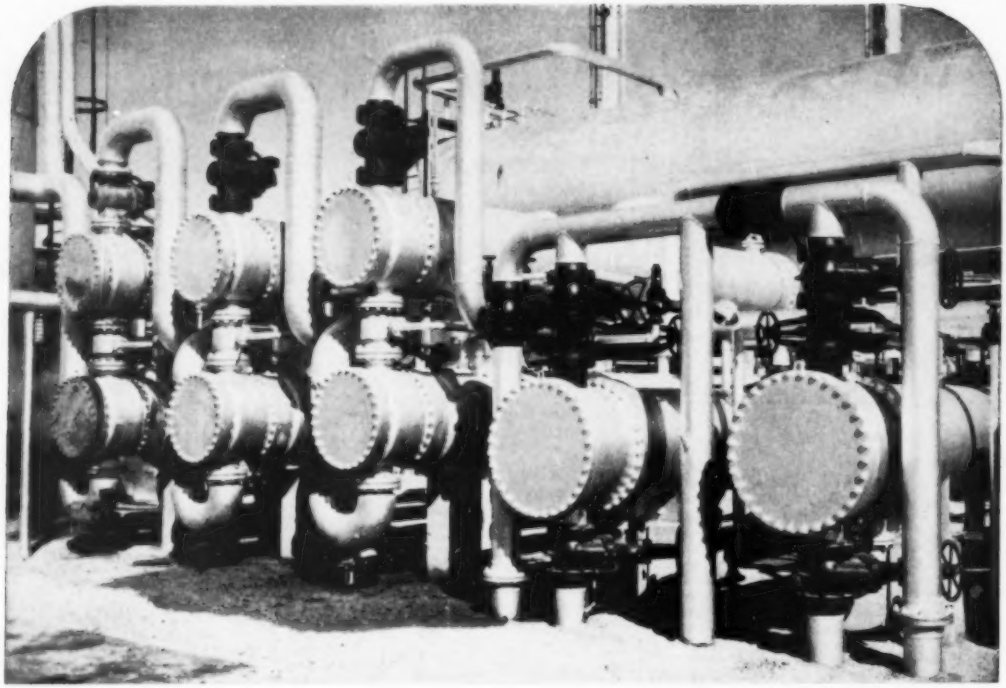
The tapes are used for above-ground or buried pipe in such applications as pipelines, tank farms, chemical works, gas and water mains and service lines and on magnesium insulated steam lines where corrosion is a problem.

Circle No. 18 on Postcard

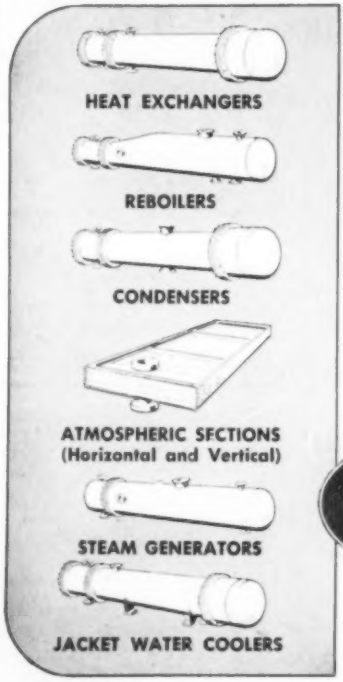
Durable Conveyor Belt

A new type of conveyor belt that is said to be rip-proof has been offered by New York Belting & Packing Company. For use particularly where conveyor belts may be subject to severe ripping or tearing action by foreign objects, the belt has a special carcass of multiple strands of high tensile steel wires imbedded at three-foot intervals. Tearing is thus restricted to a maximum of about three feet lengthwise.

Circle No. 19 on Postcard



Make sure your Heat Exchangers are



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EFCO

HEAT TRANSFER EQUIPMENT

Low Temperature Separation

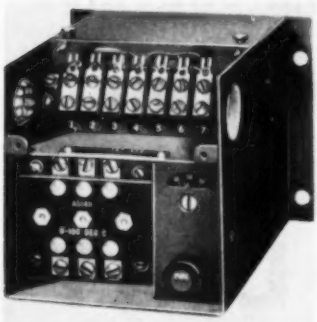
"The Linde-Fraenkl Process—Low Cost Tonnage Oxygen Production," a 24-page booklet recently published by the chemical plants division, Blaw-Knox Company, describes oxygen and other low temperature separation processes as developed by Gesellschaft fuer Linde's Eismaschinen A. G. Included in the booklet is a description and flow sheet of the Linde-Fraenkl Process plus information on typical plant layouts. The bulletin will be furnished to executives and engineers when requested on company letterheads.

Circle No. 20 on Postcard

Liquid-Level Control

A new 12-page bulletin issued by Moore Products Company describes with graphs and illustrations the Moore Liquid-Level Controller. The booklet is divided into sections which show the principle of operation, advantages, specifications and many other points of the equipment.

Circle No. 21 on Postcard



Temperature Transmitter

The thermometer adapter unit shown above together with a resistance thermometer element are the two major assemblies comprising The Swartwout Company's new temperature transmitter.

For use in chemical and food processing plants, refineries, petrochemical plants and central stations, and primarily with the all-electronic Swartwout Autronic Control System, the unit is known as the Swartwout Type T2T Autronic Temperature Transmitter.

Circle No. 22 on Postcard

Centrifugal Compressors

An illustrated, 12-page bulletin on American Blower Corporation's line of single stage centrifugal compressors has been issued. Designated Bulletin No. 109, it covers the compressor's functions, applications, ratings, features of design, arrangements and methods of control.

Circle No. 23 on Postcard

Fire Protective Transfer

Designed for greater safety, the new Protectoseal transfer pump provides protection against explosion and fire hazards in the movements of hazardous liquids from receiving drums to use containers.

Three flame arrestors are built into the pump and are an integral part of it. The pump is self-priming and is constructed of special aluminum alloy with a brass telescopic tube for strength and resistance to corrosion.

Circle No. 24 on Postcard

Coatings Measure

A six-page folder describing theory and operation of the "Coatingage" Model 600 has been released by Branson Instruments, Inc. Used to measure the thickness of non-magnetic coatings on magnetic bases and to detect pin-holes in non-conductive coatings on conductive bases, this portable instrument has been successfully used in examining corrosion-protective coatings for thickness and film continuity.

Circle No. 25 on Postcard

Dealkalization Process

New process equipment for softening and dealkalizing water and increasing the capacity of anion exchange resins by 50 percent has been announced by American Water Softener Company. It is claimed that the dealkalizing equipment saves up to a third over more conventional methods.

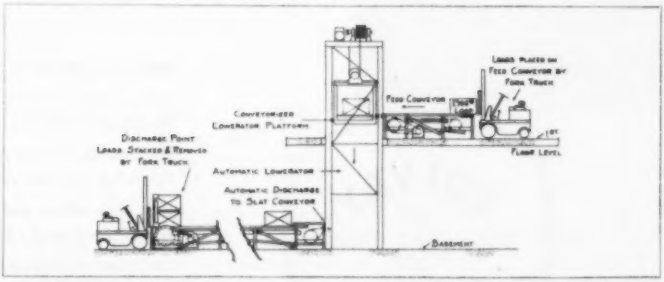
Circle No. 26 on Postcard

Drum And Barrel Handling

A new automatic attachment for drum and barrel handling with Yale gasoline and electric fork trucks has been made available by The Yale & Towne Manufacturing Company. Called the Marvel Lift-O-Matic, it will handle any drum regardless of bead or rim size and can be attached to a Yale fork truck in a few minutes.

Drums can be tiered or removed at maximum fork height without the use of pallets, and, because there are no side clamps or projections, drums can be picked up and spotted in close positions. No additional controls are required for the unit.

Circle No. 27 on Postcard


Loads Placed on Feed Conveyor by Fork Truck
Feed Conveyor
Conveyor-Lift Lowerator Platform
1st Floor Level
Discharge Point Loads Stacked & Removed by Fork Truck
Automatic Lowerator
Automatic Discharge to Slat Conveyor
Basement

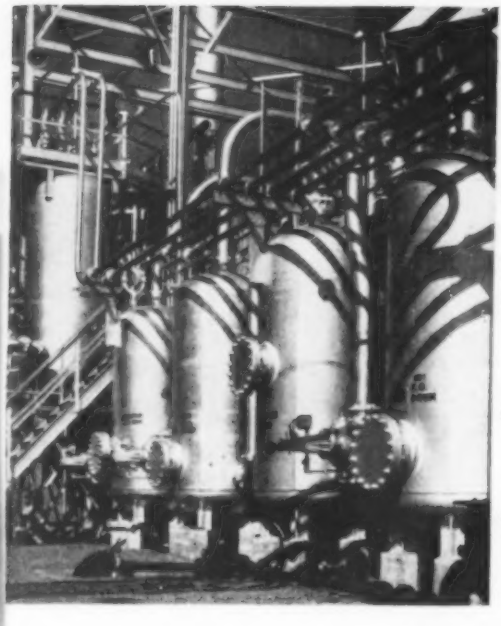
Inter-Floor Handling

An automatic lowerator-conveyor system has been announced by the Gifford-Wood Company. Particularly applicable where fairly large quantities of materials must be transported between floors with relative frequency, the system comprises three major units: (1) the lowerator, (2) a feeder conveyor, and (3) a take-off conveyor. All three units are automatically interlocked and controlled by electric eyes and limit switches so that the system runs through the entire operation of transportation automatically.

The lowerator and conveyor are constructed to fit given space requirements and to handle specific loads.

Circle No. 28 on Postcard

NEED these Quality Products for Petroleum Processing?



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Ammonium Chloride

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[What's New in Equipment]

Automatic Drum Filler

Capable of filling 1000 drums of 53 to 55 gallon capacity per eight-hour shift with a single operator, the automatic drum filler announced by the Rucker Company is said to bring about substantial savings in filling costs and in material losses due to over-filling.

Empty drums are fed to the unit by gravity roller conveyor. The filler, used for oils and other liquids, admits one drum at a time, automatically locates the bung and positions the drum.

Circle No. 29 on Postcard

Gas Detectors

The MSA Explosimeter, Model 2, a portable instrument developed by Mine Safety Appliances Company for use in detecting hazardous gas or vapor-air atmospheres, has been listed by Underwriters' Laboratories, Inc.

A special filter cartridge, incorporating a chemical reagent, used with the instrument when sampling leaded gasoline vapor, is also listed.

Circle No. 30 on Postcard

Exhaust Protectors

Offering improvements on other vertical exhaust protectors, Canton Cast Products Company's "Cancap" is the result of a redesign job based on testing and performance. Of lightweight cast aluminum alloy fused around the top of a malleable tear-shaped hinge, the cap is light enough to open with the first puff of exhaust and strong enough to give the hinge strength for long life.

A wider opening action is gained and insured by using a cadmium plated set screw with a shakeproof washer as the pin of the hinge. Cancap also has a malleable mounting bracket which is held by a cadmium plated set screw.

Circle No. 31 on Postcard

Multi-Purpose Hose

Multi-purpose hose is described in a new pamphlet published by The Thermoid Company entitled: "Basic Five" Multi-Purpose Hose. The five new types replace 18 hose types formerly stocked.

Circle No. 32 on Postcard

Plating Deposits

"High Speed Nickel Plating," an eight-page booklet published by The International Nickel Company, Inc., describes the results of investigations of plating deposits of .001 inch to .003 inch in eleven minutes (at current densities of 100 to 300 amperes per square foot).

Plating solutions and procedures are also included.

Circle No. 33 on Postcard

Equipment and Auto Covers

Made of DuPont ten gage Vinylite, American Agency's new tarpaulins are half the weight of duck tarpaulins and cost half as much. Claimed to be more durable and tough than duck tarpaulins, these coverings are 100 percent waterproof, crackproof, peelproof; resistant to abrasion, motor oils and most chemicals. Non-inflammable, they will not warp or shrink after prolonged weathering and exposure to wide temperature fluctuations.

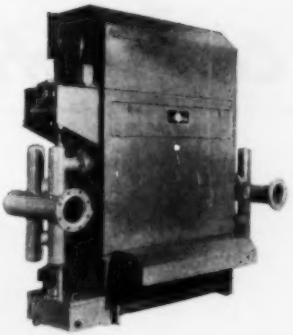
Circle No. 34 on Postcard

Midget Packing Gland

Designed as a standard seal for entry of small dial-type thermometers, thermocouple wells, pitot tubes, static pressure probes, round rods or tubes or even insulated electric lines, Conax Corporation's new midget packing gland may be used as a standard male connector for tube ends or as a standard compression fitting. In either application, the soft sealant used will not damage the tube.

The Conax MPG is machined entirely from Type 303 Stainless Steel cold drawn bar stock for maximum corrosion resistance, trouble-free operation and interchangeability from one process to another.

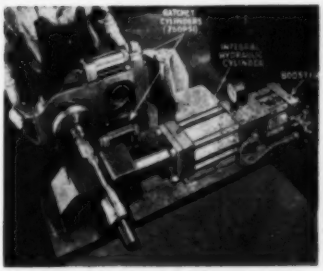
Circle No. 35 on Postcard



Coolers For Compressed Air

Niagara Blower Company has announced a new improved design of the Niagara Aero After Cooler for compressed air or gases, in which the cooling capacity of the units is increased from 25 to 75 percent over previous models. Cooling is done by the evaporation of re-circulating water sprays on the surface of tubes thru which the compressed air passes. The cooling medium is air at the atmospheric wet bulb temperature which is cooler than the average summer temperature of surface cooling water. The cooler consumes less than five percent of the cooling water required by conventional after coolers, the company claims. Freezing is prevented in winter by automatic control which shuts off freezing cold air from the spray chamber.

Circle No. 36 on Postcard



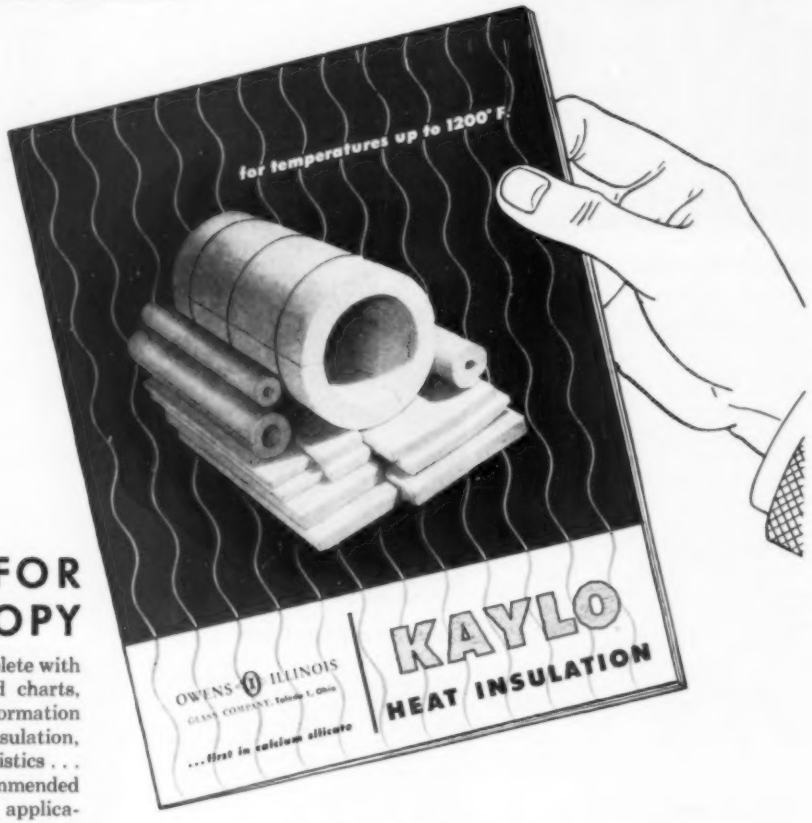
Unique Clamping Device

Holding chrome plated steel piston rods tight at over 15 tons of clamping pressure to permit fast assembly of piston and followers to the rod is the job performed by the clamping device designed and built by the Plant Products Corporation in conjunction with Miller Motor Company.

A small hydraulic pump operating at 250 psi. powers the entire device. The 15 tons clamping pressure is obtained by use of a standard Miller five-inch bore B4 Fluid Pressure Booster. Brass "V" jaws on the clamp prevent marring of the polished rod finish under the tremendous clamping pressure developed.

Circle No. 37 on Postcard

Every User Can Profit of Heat Insulation From This New Book



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This useful book, replete with pictures, graphs and charts, contains specific information on Kaylo Heat Insulation, including characteristics . . . efficiencies . . . recommended thicknesses . . . and application data for pipes, vessels and flat surfaces. For your free copy of this book, write: Dept. N-246, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

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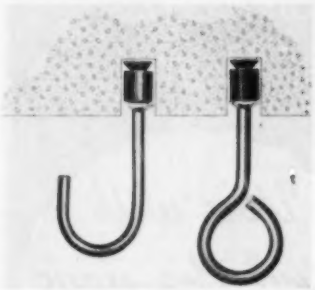
[What's New in Equipment]



Anchoring Assemblies

A new pipe bolt anchoring assembly and a new eye bolt anchoring assembly has been developed by Super-Grip Bolt Company, Inc. The pipe bolt assembly is used for mounting conduit, gas and water pipe to masonry while the eye bolt assembly is used for anchoring guy wires to masonry. Both assemblies are said to provide 50 percent greater anchorage.

The pipe bolt assembly replaces pipe straps, anchors, screws and bolts. Both assemblies are rust proofed.

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Pressure Control

The Swartwout Company has announced a new six-page bulletin on the Swartwout Autronic Controller. In addition to giving a brief resume of the Autronic principle, the folder describes the instrument in detail. Printed in two colors, it is illustrated with photographs and dimensional drawings.

Circle No. 39 on Postcard

Industrial Insulations

A 20-page, illustrated booklet describing Baldwin-Hill Company's line of industrial insulations has been released by that company.

Circle No. 40 on Postcard

Static Electricity Ground

A built-in device which grounds static electricity and eliminates shock to operators of carbon dioxide fire extinguishers having hose connections, has been developed by American-LaFrance-Foamite Corporation. The Alfco Anti-Statik Horn is a means of eliminating the building up of a static potential under all operating conditions. A pair of copper conductor strips, extending a considerable distance along the inside surface of the horn, are molded in place and electrically bonded through the nozzle and the metal braid of the hose to the carbon dioxide cylinders.

Circle No. 41 on Postcard

Precision Rotary Table

Electronics, aircraft and automotive manufacturers will be interested in The Kenco Manufacturing Company's new 12" Rotary Table. Made of sorbocast casting for strength and with four longitudinal T-slots for versatility, the Kenco 12" rotary table has a 7¾ diameter hold-down ring for added rigidity. Its top is graduated from 0° to 360° and the dial is graduated in minutes. Its accuracy is guaranteed within .0005 inches in concentricity run out and .001 in parallel to base.

All working parts in the unit are completely enclosed to protect them against grit, dust and dirt.

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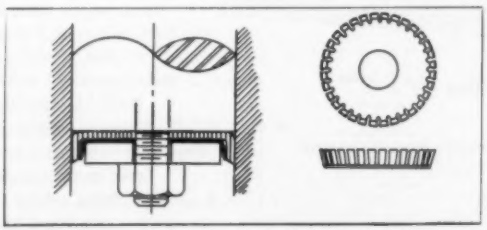

Sealing Cup Expanders

The availability of a new line of cup expanders, designated ES-11, has been announced by HPL Manufacturing Company. Developed to eliminate leakage in hydraulic and pneumatic cylinders, the expanders insure sealing action of cup packings at all times by exerting controlled pressure on the packing lip; thus the lip maintains constant contact with the cylinder wall and effective packing life is increased and leakage due to packing shrinkage is eliminated.

Circle No. 43 on Postcard

Smoke Indicator

A simple and direct method of maintaining a continuous check on overall combustion efficiency and a way to check plant smoke conditions to see that they are within limits established by municipal ordinances have been announced by Combustion Control Corporation.

The company's Fireye Photoelectric Smoke Indicator, consisting of a light source, a photoelectric scanner and a control and indicator combined into a single housing, continuously registers the density of smoke passing through the stack of a power plant. When the smoke density exceeds a preset valve, the Indicator signals.

Circle No. 44 on Postcard

Seal-Less Centrifugal Pump

The Chempump Corporation has announced the development of a new type of pump. Called Chempump, the seal-less centrifugal pump has no couplings—the motor and impellor are one integral unit. The main features about the new product are that it eliminates seals and stuffing boxes and does not require external lubrication.

Circle No. 45 on Postcard

Stainless Tubing Steels

Two economical stainless tubing steels having the attributes of resistance to corrosion and oxidation, and also the ability to be hardened by heat treatment to develop good mechanical properties, are discussed in Technical Data Card 143, recently issued by the Tubular Products division of The Babcock & Wilcox Company.

Circle No. 46 on Postcard

Tube Expanders Described

The Gustav Wiedeke Company has issued a folder describing many of the companies products. The illustrated booklet marks Wiedeke's Sixtieth Anniversary.

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Covers, annealing (elevator furnace)
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Flights, conveyor (syn. rubber plant)
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Manifolds, gas exhaust
Muffles, carburizing
Piping, process (alloy only)
Pots, carburizing & annealing
Pots: lead, cyanide & salt
Racks, annealing & carburizing
Racks, sheet pickling
Retorts, carburizing
Rings, neck (compressed gas cylinder)
Tanks, copper annealing
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TUBE CLEANERS — Information. The Airetool Manufacturing Co. See page 209.
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STEEL FLOOR PLATE—Booklet A-18. Alan Wood Steel Co. See page 206.
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ROTARY PUMPS—Bulletin LG. De Laval Steam Turbine Co. See page 243.
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WATCHMENS CLOCKS—Circular. Detex Watchclock Corp. See page 235.
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TUBE CLEANERS—Bulletin Y-29. Elliott Co. See page 236.
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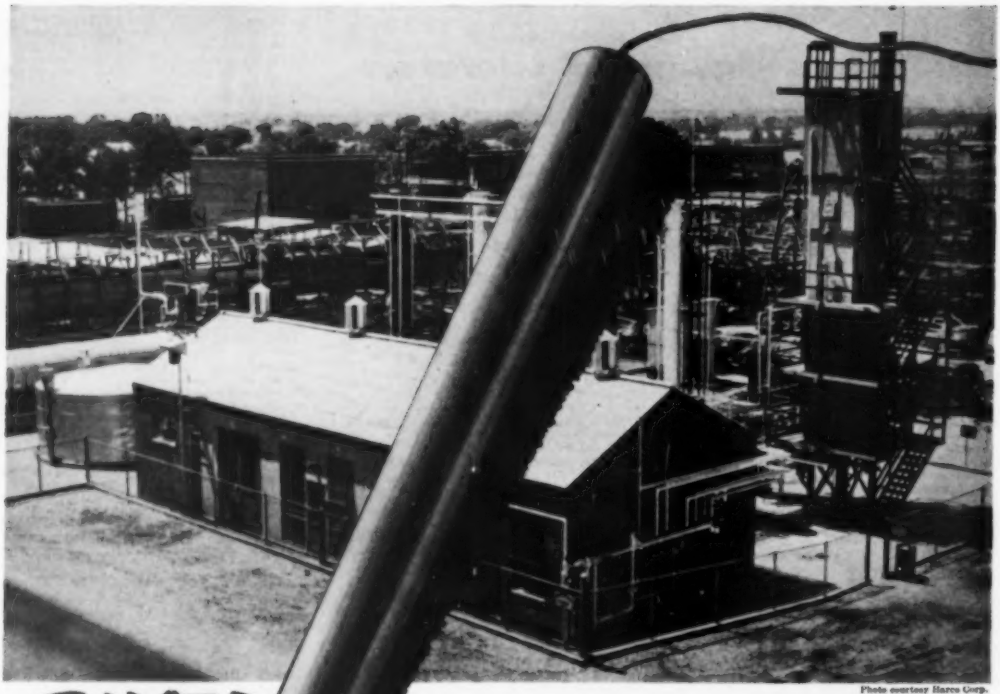

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[New Science and Technology Abstracts]

Fundamental Physical and Chemical Data—

Phase Behavior in the Hydrogen Sulfide-Water System.

F. T. Selleck, L. T. Carmichael, and B. H. Sage (California Institute of Technology, Pasadena 4, Calif.), *Ind. Eng. Chem.* **44** (1952), pp. 2219-26.

Hydrogen sulfide is frequently a component of petroleum or of natural gas. The equilibrium pressures at 3-phase states associated with one of the quadruple points of hydrogen sulfide-water systems were determined at temperatures between 40 and 340 F. Over this temperature range the bubble point pressure of the aqueous liquid phase was determined as a function of composition and temperature at states where hydrate was not encountered, and for pressures up to 2500 psia. The quantity of water in the gas phase was studied in the same range of temperature and for pressures up to 5200 psi. A few measurements of the specific volume of homogeneous and heterogeneous mixtures of water and hydrogen sulfide were made. Data reported as the result of the work were found to be in good agreement with earlier investigations made by other workers. The phases involved were an aqueous liquid, a hydrogen sulfide rich liquid and the gas phase. The data should be of help in estimating the distribution of hydrogen sulfide between the gaseous and aqueous phases of petroleum reservoirs. Hydrates of hydrogen sulfide exist at temperatures as high as 90 F. for pressures in the neighborhood of 7000 psi. The data are presented in tabular and graphical form and a bibliography of 24 references is included.

3-Thiapentane: Heat Capacity, Heats of Fusion and Vaporization, Vapor Pressure, Entropy, Heat of Formation and Thermodynamic Functions.

D. W. Scott, H. L. Finke, W. N. Hubbard, J. P. McCullough, G. D. Oliver, M. E. Gross, C. Katz, K. D. Williamson, Guy Waddington and H. M. Huffman (The Thermodynamics Laboratory, Petroleum Experiment Station, Bureau of Mines, Bartlesville, Okla.), *Jour. Am. Chem. Soc.* **74** (1952), pp. 4656-62.

The thermodynamic properties of 3-thiapentane were determined experimentally. These included the heat capacity of the solid and liquid between 15 and 320 K., triple point, heat of fusion, vapor pressure, heat of vaporization, heat capacity of the vapor, second virial coefficient of the vapor, entropy of the liquid, entropy of the vapor and heat of formation. Various functions were calculated from spectroscopic and molecular structure data. The values of the height of the potential barriers hindering internal rotation, which are used in the calculations, were evaluated from the experimental entropy and heat capacity data. Heat of formation, free energy of formation and the equilibrium constant of formation of 3-thiapentane were calculated for selected temperatures up to 1000 K.

A Calorimetric Determination of the Vapor Heat Capacity and Gas Imperfection of Water.

J. P. McCullough, R. E. Pennington and Guy Waddington, *Jour. Am. Chem. Soc.* **74** (1952), pp. 4439-42.

Although water has been the subject of intensive thermodynamic study, the variation of the vapor heat capacity with pressure at pressures below atmospheric has not previously been studied. For this reason the heat capacity of water was investigated at pressures from ⅛ to 1 atmosphere at each of five temperatures between 361 and 487 K. It was found that the vapor heat capacity is not a linear function of pressure. An equation of the vapor heat capacity as a function of temperature and pressure was derived and is given. In the range of conditions studies, the equation represents the data to within ±0.1 percent and agrees with values of the specific heat computed from spectroscopic and molecular structure data to within 0.05 percent. The data are presented in some detail in tabular and graphical form.

Vapor-Liquid Equilibria. 2-Propanol-Water System.

Abraham Wilson and Edward L. Simons (Rutgers University, New Brunswick, N. J.), *Ind. Eng. Chem.* **44** (1952), pp. 2214-19.

Vapor-liquid equilibrium data were obtained for the system 2-propanol-water at pressures ranging from 95 mm. to 4.06 atmospheres. Over this pressure range the azeotropic composition varied from 69.5 to 66.7 mole percent 2-Propanol. The azeotropic boiling points are approximately 2 C. lower than those of pure 2-propanol at the same pressure. Curves of the loss of the vapor pressure against the reciprocal of the absolute temperature for the azeotrope 2-propanol and water are substantially parallel, thus indicating that azeotropic behavior will disappear only at pressures considerably higher than four atmospheres. Equations are presented for the effect of pressure on the azeotropic boiling point. The apparatus used in the work is described in some detail. The data are presented in tabular and graphical form and a bibliography of 24 references is included.

THESE abstracts prepared by DR. E. H. LESLIE and DR. H. B. COATS, The Leslie Laboratories, Traver Road, Ann Arbor, Mich., are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles can be obtained at nominal cost from The Library of Congress, Photoduplication Service, Washington 25, D. C. Complete or limited bibliographies covering special topics by title, by abstract or in complete manuscript will be prepared and furnished by arrangement with The Leslie Laboratories.

Vaporization Rates and Heat-Transfer Coefficients for Pure Liquid Drops.

Robert D. Ingebo (National Advisory Committee for Aeronautics, Cleveland, Ohio), *Chem. Eng. Progress* **48** (1952), pp. 403-8.

The design of high-output combustors for jet-propelled aircraft and such equipment as spray dryers and cooling towers requires accurate knowledge of liquid vaporizaton rates. In the work on which a report is made vaporization rate data and surface-temperature data were obtained for nine pure liquids evaporating from the surface of a porous sphere. The experimentally determined heat-transfer coefficients were found to correlate a semi-empirical equation that expresses the Nusselt number for heat transfer as a function of a new dimensionless number and the thermal conductivity ratio. The liquids studied were nitrobenzene, n-octane, benzene, methanol, acetone, water, ethanol, butanol, and carbon tetrachloride. The surface temperatures found were approximately equal to wet-bulb temperatures. A new procedure for predicting wet-bulb temperatures from boiling-point data and wet-bulb data for water was developed and was explained. A bibliography of six references is included.

Heat-Transfer Coefficients for Industrial Gases.

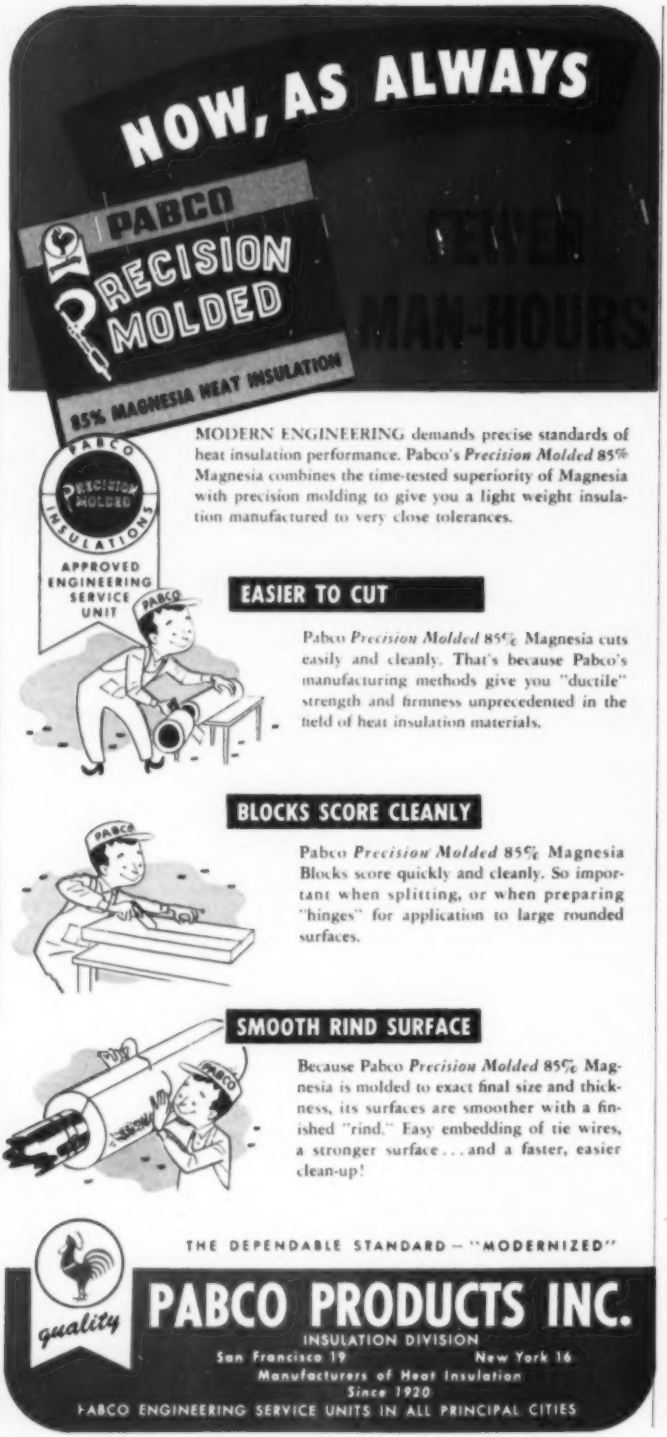
F. W. Lohrisch (Henry Balfour & Co., Ltd., Durie Foundry, Leven, Fife), *Jour. of Applied Chem.* **2** (1952), pp. 464-9.

The author presents useful information for the calculation of heat-transfer coefficients for heat exchangers, gas coolers, waste-heat boilers and similar devices. Although the literature provides formulae for these coefficients the author states that it is frequently difficult to assemble all the data in terms of the required dimensions. This is especially true for those who deal with the subject infrequently. Properties of the common gases are presented in tabular form including those for oxygen, nitrogen, air, carbon monoxide, hydrogen, carbon dioxide, water, methanol, and ethane. The properties given are density, absolute viscosity, kinematic viscosity, thermal conductivity, specific heat at constant pressure, and specific heat at constant volume. Recent and reliable data for the thermal conductivity of the gases are presented in another table. Charts are given for the estimation of the heat transfer coefficients between air and a single tube and between a pipe and the fluid flowing in it. Equations upon which the heat-transfer coefficients are based are given.

Activated Alumnia. Heat of Wetting by Water. Heat of Wetting by Hydrocarbons.

Vernon M. Stowe (Aluminum Co. of America, E. St. Louis, Ill.), *J. Phys. Chem.* **56** (1952), pp. 484-9.

The heat of wetting on adsorption of a monolayer of water on activated alum-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[Science Abstracts]

ina was measured. It was found to be in the range 150-190 cal./g. H_2O adsorbed, and was not greatly affected by different grades of alumina. Heat continued to be evolved as adsorption occurred in additional layers. Measurements were also made of the heat of wetting by n-heptane, an isomeric heptane, toluene, and methylcyclohexane. The heat evolved was least for the paraffins and greatest for the naphthalenes. When water was added to alumina on which heptane was adsorbed there was a large further heat evolution. Activated alumina shows preferential adsorption for water but no preferential adsorption for any specific type of hydrocarbon was observed.

Manufacture: Processes And Plant—

Chemical Engineering Unit Processes. *Ind. Eng. Chem.* **44** (1952), pp. 1967-2100.

This is the fifth annual unit processes review presented by Industrial and Engineering Chemistry, and which includes the outstanding developments in unit processes during the past year. The reviews of Hydration, Hydrolysis and Isomerization, which were not presented in 1951, cover the developments of the last two years. The subjects covered are Alkylation, Amination, by Reduction, Ammonolysis, Esterification, Fermentation, Friedel-Crafts Reactions, Halogenation, Hydration and Hydrolysis, Hydrogenation and Hydrogenolysis, Isomerization, Nitration, Oxidation, Polymerization, Pyrolysis of Coal and Shale, Pyrolytic and Catalytic Decomposition of Hydrocarbons, and Sulfonation and Sulfation. Each article includes a long bibliography of references to the literature.

Perforated-Plate Distillation Columns. F. Drew Mayfield, Walter L. Church, Jr., A. C. Green, D. C. Lee, Jr., and R. W. Rasmussen (Chemical Division, Celanese Corporation of America, Bishop, Texas), *Ind. Eng. Chem.* **44** (1952), pp. 2238-49.

Perforated plates were studied to obtain data for general application, which data have not hereto been available. The authors report experimental data and visual studies made when using a 6-inch diameter column and also a 6½-foot diameter experimental tray. The 6½-foot tray showed a wide range of stable tray operations. Efficiency data are reported on a 6-foot diameter 60-tray perforated-plate column, and a comparison is made to a 2-foot diameter, 35-tray bubble-cap column, both of which were operated using the system n-propyl alcohol secondary butyl alcohol under total reflux. The perforated plate column showed a higher plate efficiency. A wide range of vapor rates with good efficiency was demonstrated for the sieve-plate column. Methods of design for commercial size sieve-plate columns are suggested and illustrated. The work reported has led to the selection and design of sieve plate columns for 68 applications. These varied from 2 to 11 feet in diameter. Sieve trays were chosen rather than bubble-cap trays because of higher efficiency, some-

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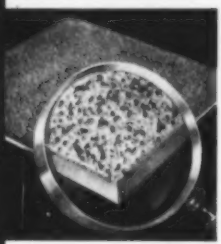

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A Note on the Correlation of Flooding Rates for Packed Gas-Liquid Columns.

F. R. Dell and H. R. C. Pratt (Ministry of Supply, Chemical Engineering Division, Atomic Energy Research Establishment, Harwell, Berks), *Jour. of Applied Chem.* **2** (1952), pp. 429-435.

The authors briefly review literature on the flooding rates of packed columns. It appeared probable that a theoretical equation previously proposed by the authors for use in connection with liquid extraction columns could be applied with slight modification to gas-liquid systems. The results of an investigation of this subject are described in the article. Available experimental data show good agreement with the proposed equation up to a critical value of a group on the right hand side of the equation. Beyond this critical value the exponent changes sharply. Derived values of the constants in the equation are given for four types of packing, and the application and limitations of the equation are discussed. The authors conclude that the equation given represents the best correlation to date of the available flooding data for packed absorption and distillation columns. It is not, however, applicable to ¼-inch size of packings, nor to ½-inch size when the liquids in the columns are of high viscosity. A bibliography of 13 references is included.

Droplet Behavior in Packed Columns.

J. B. Lewis, I. Jones, and H. R. C. Pratt (Energy Research Establishment, Harwell, England), *Trans. Inst. Chem. Engrs.* (London) **29** (1951), pp. 126-44, discussion, 144-8.

Formation and breakdown of droplets in packed liquid-extraction columns were studied in a 2-inch internal-diameter column with a packed height of 3 feet. Experiments were made with nine different liquid-liquid systems and six packings, and photographs were taken that could be projected on a screen. The mean diameter of the droplets leaving the column is independent of the size of those entering. There appears to be a critical size of packing, depending upon the equilibrium droplet diameter, above which the latter is independent of the packing size and type. The mean droplet diameter is independent of the flow rate of the dispersed phase until the flooding rate is approached, but increases slowly with the flow of the continuous phase. With packings below the critical size the mean droplet diameter is greater, although still independent of the dispersed-phase flow rate. Equations are given that express mean droplet diameter in terms of the physical properties of the system.

Liquid-Liquid Extractor Design.

F. Drew Mayfield and Walter L. Church, Jr. (Chemical Division, Celanese Corporation of America, Bishop, Texas), *Ind. Eng. Chem.* **44** (1952), pp. 2253-60.

The work reported was undertaken to make a study of the type of equipment best suited for "clean-service" liquid-

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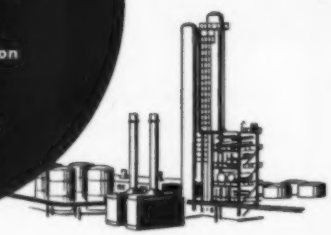

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liquid extractions. Visual studies were made using an 8½-inch diameter glass column. These indicated that perforated plates (or jet plates) should be effective and operable over a wide range of throughputs. Stage efficiency studies of perforated and/or jet plates in a 2-inch i.d. glass column operated on the system toluene, benzoic acid and water, and also on ethyl acetate-acetic acid-water at throughputs up to 49 gallons per minute per square foot gave good stage efficiencies, in the range 16 per cent to 100 per cent except for low ratios of dispersed to continuous phase. It was concluded that perforated plate-type extractors offer an excellent method for effecting liquid-liquid extractions. Mechanical design and operating conditions are very important. The commercial scale unit is a simple device low in maintenance and easy of access. Best success is to be expected if the liquid flowing in larger volume is dispersed and if jet type perforated trays are used as precaution against the wetting of the tray by the dispersed phase. The trays are operated at or above the streaming velocity in order to create internal turbulence within the droplets, thus to insure more uniform droplet size and to minimize surging of the dispersed phase through the trays.

Hydrocarbon Reforming Processes.

H. E. Bramston-Cook (Oronite Chemical Company, New York), *Chem. Eng. Progress* **48** (1952), pp. 381-4.

The author traces the history of production and use of the aromatic hydrocarbons, benzene, toluene, xylene and naphthalene, and then describes several processes, such as hydroforming, platforming, houdriforming and other processes using a platinum catalyst. The petroleum industry is rapidly assuming a dominant position in the manufacture of benzene and other aromatics. The normal demand for benzene is estimated as 262 million gallons in 1953, or with mobilization at 338 million gallons. The supply, assuming that 100 million gallons per year will be available from petroleum, will be approximately 345 million gallons by the end of 1953, and there should be a close balance between the supply and demand for 1953, provided there is no serious construction delay in the building of new benzene plants.

A Liquid-Dowtherm Heating and Cooling Unit.

T. G. Stack and J. E. Friden (Standard Oil Company [Indiana], Whiting, Indiana), *Chem. Eng. Progress* **48** (1952), pp. 409-12.

A problem frequently encountered in the design of pilot-plant equipment is that of rapidly heating or cooling process vessels. The authors describe a system used to maintain reaction temperatures in the temperature range of 125 to 650 F. Dowtherm A in the liquid state was the heat-transfer medium employed in essentially independent heating and cooling systems. The hot stream and the cold stream of Dowtherm were blended to give the desired regulated temperature. Experience with the installation over a period of three years has

PETROLEUM CHEMICALS DIVISION

NEWS

November ★ One of a Series of Interest to the Petroleum Industry ★ 1952

YOUR CUSTOMERS...Have you recently reminded them of these rules for good driving?

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2. Drive the road ahead. Watch traffic and lights. Pace driving to make as few stops as possible.
3. Make slow easy starts. Shift to high as soon as possible.
4. Under normal driving conditions, don't press the accelerator to the floor.
5. Avoid sudden stops.
6. Adjust seat so legs are comfortable for a light steady pressure on the accelerator. Don't pump the pedal!
7. On open stretches maintain a constant speed.
8. On up-grades don't attempt to maintain constant speed.
9. Be sure tires are inflated to proper pressure.
10. Use the proper grade lubricants for anticipated seasonal weather conditions.

Complete Manual on Gasoline Dyes Soon Available

New booklet on Du Pont Gasoline Dyes contains all the information a refiner needs to know about dyeing gasoline.

Ever since tetraethyl lead was first used as an antiknock compound, coloring has been an important factor in making gasoline.

Gasoline dyes, however, have for a long time presented a number of han-

dling problems. And it was not until recently that efficient methods of addition were worked out.

All of the latest methods of dyeing gasoline are fully discussed in a new booklet, "Du Pont Gasoline Dyes." It covers the dry dye eductor system as well as the various other methods of addition by dye pot.

The booklet also gives complete information – including solubility charts and spectrophotometer curves – on all the Du Pont gasoline dyes. And it contains full data on meeting color requirements for military, aviation and leaded motor gasoline.

In addition, the booklet includes much helpful information on handling dyes; such as how to remove dye stains from clothing and equipment – and useful shipping information.

This booklet will soon be available to refiners through the Du Pont Petroleum Chemicals Division district offices.

New Dynamometers Broaden Usefulness to Refiners of Du Pont Test Car Fleet

When a car engine knocks, the cause may be from a variety of factors other than gasoline quality. This fact is readily demonstrated to fleet owners or other groups by the new Petroleum Chemicals Division traveling dynamometers which are part of Du Pont's fleet of 53 road octane test cars.

ROBERTS W. BROKAW, JR., Du Pont representative, uses the Du Pont test car and dynamometer combination for demonstrating road knock by the Uniontown method.

Suppose you want to show a customer group the effect of speed, spark advance, air-fuel ratio, operating temperature, and altitude as well as fuel quality on engine performance and octane requirement. The dynamometer and Du Pont test car combination is all that is needed to make a convincing demonstration.

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Suppose, on the other hand, you want to refute quality complaints with a dash of real showmanship. The dynamometers can be employed to point up the effect of poor operating maintenance on engine performance . . . by simulating faulty ignition, fouled spark plugs, over-advanced spark timing and improper carburetor adjustment.

OVER

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PETROLEUM CHEMICALS DIVISION
NEWS

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Refiners and marketers who are interested in learning about this new sales promotion tool should get in touch with the nearest Du Pont Petroleum Chemicals Division district office for details.

Copper Picked Up By Gasoline in Pipeline

It is often difficult to trace the exact source of contamination when copper is found in gasoline. Therefore, the following case history of copper picked up by gasoline during pipeline transfer is of interest.

A new products pipeline was recently put into operation by an oil company. Gasoline entering this pipeline with an induction period of 14 hours was found to leave the pipeline 416 miles away with an induction period of 5 hours.

To determine the source of contamination, the copper content of the gasoline was checked at various points along the pipeline. It was found to be building up in proportion to the miles traveled through the line, from .10ppm initially to .22ppm at the destination.

Further investigation showed that engines at the pump stations along the pipeline were being cooled by copper heat exchangers. And it was discovered that gasoline circulating around the copper coils, which carried water at approximately 150°F., was picking up sufficient copper to cause the difficulty. The pump impellers, which were fabricated of an alloy containing copper, were also contributing to the trouble.

At this stage Du Pont Metal Deactivator was used to counteract the copper contamination. It was found that only ¼ lb. of the deactivator per 1,000 barrels of gasoline, added at the pipeline exit, was needed to restore the original 14-hour induction period.

Normally it would be recommended to add Metal Deactivator to gasoline *at the refinery*, before it entered the distribution system.

Bernard Miller Sturgis

Bernard M. Sturgis is head of the Combustion and Scavenging Research Division of the Du Pont Petroleum Laboratory. He is in charge of fundamental research on combustion problems and on the problems associated with deposits in engines, as well as the development of and evaluation of new additives in these fields.

Sturgis joined Du Pont in 1936 after having won a 4-year Thomas A. Edison scholarship which helped him toward obtaining his Ph.D. degree in chemistry at M.I.T.

Among various duties at Du Pont's Jackson Laboratory, he did fundamental research on vulcanization and on the properties of stretched rubber. Later he was made group leader in charge of all research on chemicals for natural and synthetic rubber and on polymerizable monomers. During this time he obtained 27 patents and published several papers in this field.

Before being transferred to the Petroleum Laboratory in 1951, he was head of the Petroleum Chemicals Division of Jackson Laboratory in charge of research on tetraethyl lead, combustion and petroleum additives.

LITERATURE AVAILABLE

Here is a partial listing of the bulletins, reports, booklets and aids available to you through your Du Pont Petroleum Chemicals Division district office:

Safety for the Small Refinery – A 42-page book on how to set up an effective small refinery safety program . . . . . Serial A-2848

Tank Talk – A 52-page, easy-to-understand safety booklet for tank-cleaning crews . . . . . Serial A-1134

Stability of Present-Day Gasolines – A 12-page paper on the value of storage tests—as compared with induction period—for determining stability of modern gasolines Serial A-3199

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demonstrated that temperatures in the range 200 to 550 F. can be controlled to within one per cent.

Chemical Composition and Reactions–

The Oxidation of Hexane in the Cool-Flame Region.

H. C. Bailey and R. G. W. Norrish (Univ. Cambridge, Cambridge, England), *Proc. Roy. Soc.* (London) **A212** (1952), pp. 311-30.

The chemical nature of the cool flame of hexane at 300 C. was investigated. The results were studied in the light of a theory of combustion of the higher hydrocarbons of involving formation of aldehydes and hydroxyl radicals. Products found in the cool flame at 300 C. and in the blue flame at 310 C. are higher aldehydes, HCHO, acids, peroxides, carbon dioxide, condensable hydrocarbons, oxygen, carbon monoxide, hydrogen, methane, acetone, methanol, ethanol, butenes, pentenes, hexenes, hexane, cyclic ethers, and water. The flame mechanism is discussed. Cool flames appear to have their origin in the accumulation in the initial products of combusion of traces of hydroperoxide. These ignite in oxygen and probably release a flood of free radicals. During the peroxide ignition, and subsequent rapid reaction, intermediates, such as alkoxy radicals, are produced in sufficient numbers for their reaction to produce excited molecules of formaldehyde and to become visible.

Hydrogen Transfer Reactions Accompanying the Cobalt-catalyzed Addition of Carbon Monoxide to Olefinic Compounds.

G. Natta, P. Pino and R. Ercoli (Department of Industrial Chemistry, Polytechnic Institute of Milan, Milan, Italy), *Jour. Am. Chem. Soc.* **74** (1952), pp. 4496-8.

The cobalt-catalyzed reaction of carbon monoxide and olefins with alcohols or with amines yields esters or amides. In some cases the products formed contain added hydrogen, which is furnished by the reactants, possibly through the formation and decomposition of cobalt hydroxycarbonyl. In contrast to the ester synthesis large amounts of secondary products are seldom formed in making substituted amides from carbon monoxide and olefins with amines. The catalyst used in all cases was either Raney cobalt or cobalt-on-kieselguhr. The olefins studied included ethylene, propylene, isobutylene, styrene and cyclohexene.

Products: Properties, Utilization and Analysis–

The Deterioration of Transformer Oil. Part II. The Influence of Transformer Constructional Materials.

L. Massey (Metropolitan-Vickers Electrical Co., Ltd., London), *Jour. Inst. of Petroleum* **38** (1952), pp. 281-97.

The rate of oil deterioration in transformers is influenced by constructional

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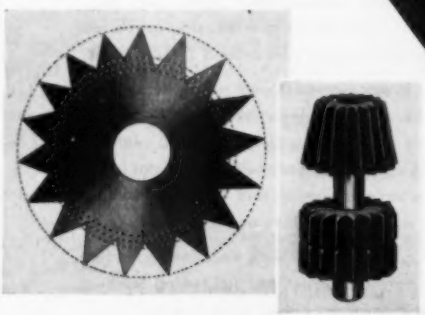

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[Science Abstracts]

materials. Experiments were conducted by study the influence of these materials on an accelerated basis and under conditions approximating transformer practice. Copper is shown to be more active than any other single material, and the reasons governing its activity or nonactivity in a transformer were investigated. Under some conditions impregnating varnishes are involved in the production of sludge and lead to erratic oil performance. The mechanism is not fully understood, but it is believed that it is associated with the formation of oil-soluble copper salts in the interior of the coils through reaction between the windings and unpolymerized varnish. Copper migrates from a coil interior to the surrounding oil. Thin films of varnish used to protect exposed metal surfaces are inert towards oil and form effective barriers isolating the metal from contact with the oil.

Some Views on the SAE Viscosity Classification.

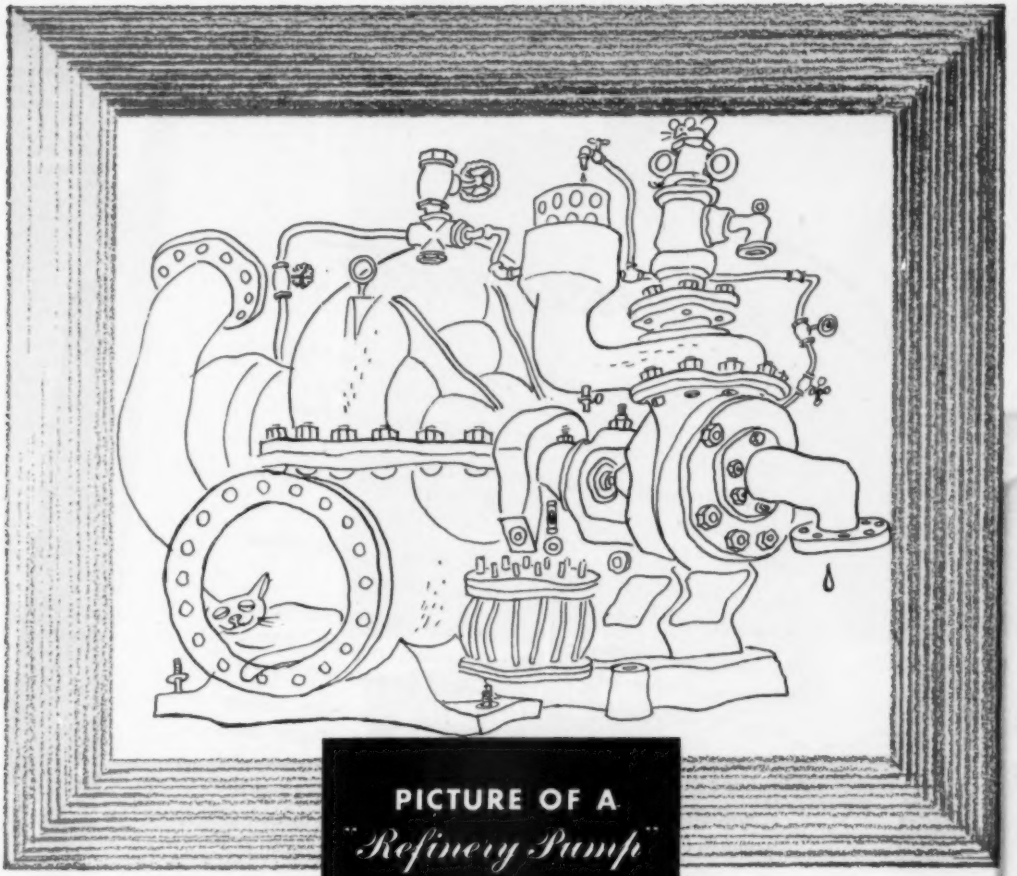
J. G. Withers (Anglo-Iranian Oil Company, Ltd., Sunbury Research Station, Sunbury, England), *Jour. Inst. of Petroleum* **38** (1952), pp. 250-6.

The SAE viscosity classification for automotive lubricating oils has proved so successful in defining marketed products that it is now used exclusively in most parts of the world. Although amendments have been made from time to time, the basic structure has remained substantially unaltered for about twenty-five years. In the author's opinion, however, there are some inconsistencies, omissions, and unnecessary complications in the SAE classification as at present published, and the purpose of the paper is to suggest minor modifications, which, it is believed, overcome these faults. The further purpose of the author's paper is to make general recommendations for viscosity grades appropriate to different atmospheric temperatures. Conditions to be met in engines are briefly recited. The author recommends that the working viscosity of all grades of engine and transmission oils should be specified in centistokes at 210 F. The limits for working viscosities should be modified slightly in line with the proposed logarithmic system. Upper working viscosity limits for the "W" grades should be added. Maximum starting viscosity should be specified in centistokes at 0 F., by specifying the maximum ratio of the viscosity at 100 to that at 210 F. Pour point should be specified as at least 15 F. below the lowest expected starting temperature. The author believes that there are considerable gains to be had from use of the less viscous oils. In Europe he recommends the use of 10W in winter and 20W in summer.

Methods for Expressing the Viscosity-Temperature Relationship of Lubricating Oils.

J. F. T. Blott (Fellow) and C. G. Verver (Fellow) (Shell Refining & Marketing Company, Central Laboratories, Fulham, England), *Jour. Inst. of Petroleum* **38** (1952), pp. 193-249.

In the first part of the paper the authors review the indices that have been



PICTURE OF A "Refinery Pump"

"Refinery" pump? There ain't no such animal. But if one pump could be all things to all processes, it *might* look like this. Fact is, however, that in refining *it's pretty important to have each pump fitted to its specialized job.* No *one* answer is good for all.

That's why Byron Jackson builds job-engineered pumps. With a BJ you're sure of a pump that sizes up to the need and is pin-point engineered to profitable performance. Starting with more than 25 basic BJ pump designs used in the refinery field, BJ engineers can incorporate features to meet particular pressure, temperature, corrosive, material or power requirements.

When you need a pump for your refinery operation—check with BJ first!

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Announcement

The Kerotest Manufacturing Company has become a wholly owned subsidiary of Tube Turns, Inc., Louisville, Ky., the nation's No. 1 producer of seamless welding fittings and flanges.

Kerotest will continue to operate under its own name. And it will continue to make the high quality steel and brass valves that have earned it an enviable reputation.

All current and future orders will be shipped as scheduled. Service and trade relationships will be improved.

Kerotest's present excellent position in the fields it serves will be further enhanced by the engineering, research, manufacturing and management resources of the parent company.

Kerotest's management and personnel have been largely retained. GEORGE O. BOOMER, *president* of Tube Turns, Inc., is now chairman of the board. JOHN G. SEILER, *executive vice president*, and ROBERT J. LANDOLT, *vice president and controller* of Tube Turns, Inc., have been appointed vice presidents. WALTER G. SWANEY, *vice president and secretary*, and J. D. ISAACKS, *vice president* of Kerotest, remain in the same capacities.

KEROTEST®

TUBE·TURN

KEROTEST MANUFACTURING COMPANY

A wholly owned subsidiary of TUBE TURNS, INC., Louisville, Kentucky

PITTSBURGH 22, PA.

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proposed for expressing, in terms of a single figure, the viscosity-temperature change of lubricating oils. The indices are divided into two groups: the non-relative indices, that is, those based on some function of the slope of the viscosity-temperature curve, without reference to any standard, and the relative indexes, involving a comparison with certain standards of reference. In the authors' opinion, only an index of the latter type can be satisfactory in practice. Considering the numbers, factors, moduli and so on, that have been advanced in the past to characterize viscosity-temperature relationship of oil, the authors have done an excellent job of getting order out of chaos and grouping and classifying the various characteristics to present an informative summary of the chief attributes of each proposal, as well as judicious and fair criticism of its shortcomings. In the second part of the paper the authors propose a relative index, which is a modification of the present Viscosity Index and for which the name Viscosity Modulus is suggested. In the modulus the logarithms are substituted for the plain values of viscosities in the calculation. The suggested index is additive for oils of the same viscosity level but different slope. The index is closely related to the functions of viscosity that are considered fundamental. Anomalous values of the index in the case of oils having a high index figure are avoided. The sensitivity of the scale is fairly evenly distributed. A procedure by means of which a value of the index between any desired temperature limits can be calculated is given. A bibliography of 28 references is included and the article is followed by a valuable discussion on the whole subject.

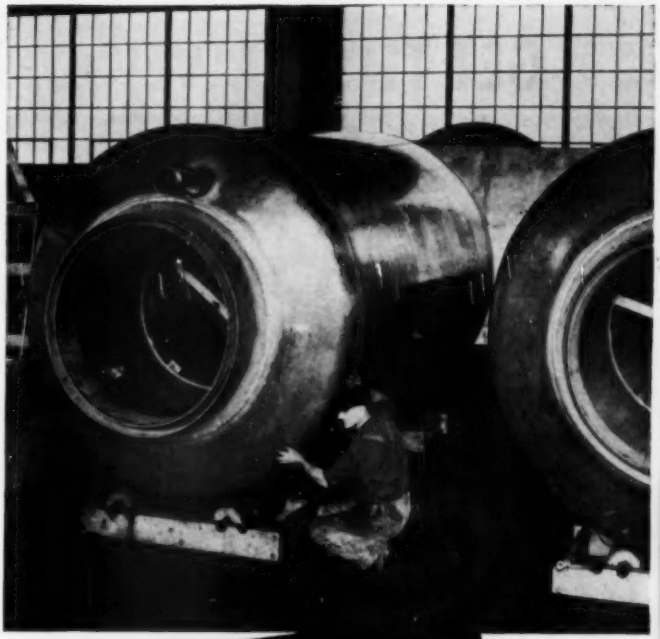
Classification of Bitumens in Asphalt Technology by Certain Rheological Properties.

Part II. The Conception and Derivation of Viscosity Number and Other Related New Indices.

S. L. Neppe, *Jour. Inst. of Petroleum*, **38** (1952), pp. 257-80.

In order to obtain truly representative samples the author prepared all necessary bitumen samples in the laboratory, using materials from 15 different sources and by suitable treatment securing 26 different series of bitumens. The same basic soft material was subjected either to steam refining or to air blowing. In the preparation of each series a number of samples of different degrees of hardness were drawn off at convenient intervals. In some cases a series comprised more than 20 samples. From the data secured in the course of the work the author made a graphical study of the inter-relationship between various rheological characteristics of asphaltic bitumens. Conclusive evidence was provided that the dimensions and shape of the penetrometer needle are responsible for certain breaks in the curves relating penetration to other properties. Three new classification methods were developed in which identical index values were assigned to each class of normal bitumens irrespective of the system used. These are:

(a) Viscosity Number—relating viscosity at any one of three temperatures



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These are the reasons why the use of aluminum equipment has spread to other fields where safety is of primary importance—petroleum processing, liquid fuel transportation, coal mines.

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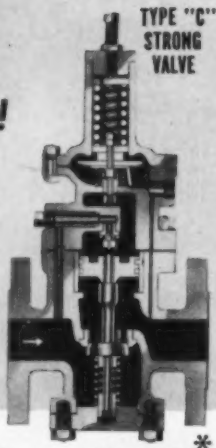

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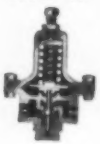

Direct operated. Semi-steel construction suitable for initial pressures to 225 psi, 400° F. For steam, air, water or gas.

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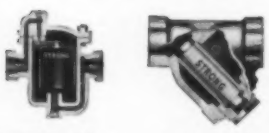

No. 070 Small Trap | "SY" Strainer | 800 Series Steel Trap

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with bitumen penetration at 77 F.;

(b) Softening Point Number—relating softening point and penetration;

(c) Softening Point Viscosity Number—relating viscosity to softening point.

The higher the Viscosity Number for a given penetration, the lower is the susceptibility to temperature change. The rational nature of the Viscosity Number chart is demonstrated by the fact that a truly linear relationship exists for all values of log log viscosity plotted against the log absolute temperature. For a given series of normal bitumens of fixed Viscosity Number, all the softening points lie in one and the same straight line. Equations are given for different classes of bitumen relating viscosities in poises with softening points. The author recommends the general adoption in bitumen investigations of a modified form of trough viscometer to give identical reading to the orifice instrument in a more rapid and convenient manner. A bibliography of seven references is appended.

Activity of Silica-Alumina Cracking Catalysts.

A Simple pH Test.

C. J. Plank (Socony-Vacuum Laboratories, Socony-Vacuum Oil Company, Inc., Paulsboro, N. J.), *Analytical Chem.*, **24** (1952), pp. 1304-6.

Previous methods of estimating the catalytic cracking activities of silica-alumina gels required a calibration curve for each type of catalyst preparation. The author reports that a simple adsorption test was developed in which the pH of an ammonium acetate solution in equilibrium with a silica-alumina catalyst gives a measure of the cracking activity of the material. Ammonium ions are adsorbed from a standard ammonium acetate solution. The pH of the solution is correlated with the cracking activity of the catalyst. A single correlation curve is satisfactory over a wide range of compositions and preparational

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

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Oxine-5-carboxylic acid
2-Methylbutyraldehyde
para-Methoxyquinoline
Divinyl sulfone
2-Chlorofluorene
2,4,5-Trihydroxytoluene
Dithioglycol
2,9-Dimethyl-1,10-phenanthroline
Ascaridole
Trimethyl boron
1,12-Benzperylene
1,2-Di(alpha-naphthyl)ethylene
0,3,3-Bicycloоctane
1,7-Dichloronaphthalene
Cyclobutyl bromide
3,5-Dinitrobenzaldehyde
Tetranaphthylmethane
3,3-Dimethylthiacyclobutane

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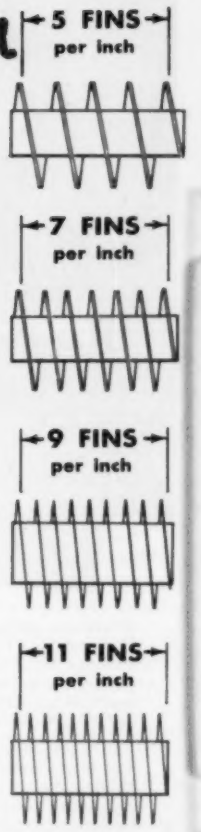

Wolverine manufactures Trufin condenser tubes in copper and copper base alloys and bi-metal in a variety of fin spacings and fin heights. —also plain condenser tubes in copper and copper base alloys.

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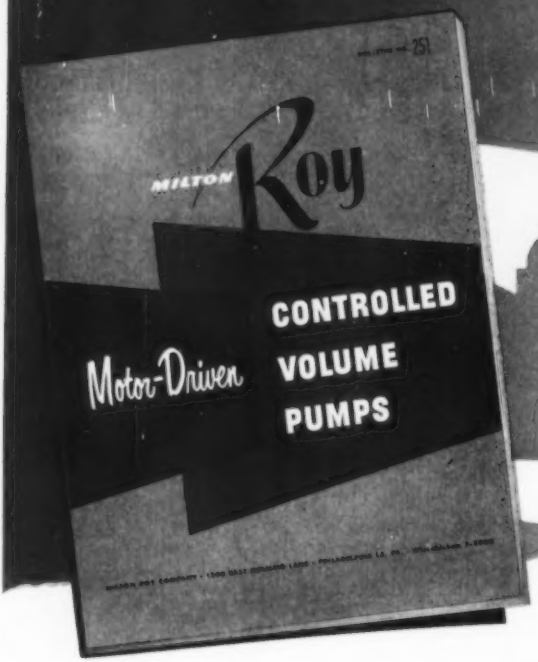
Motor-Driven CONTROLLED VOLUME PUMPS



Complete Information In These Pages

What *are* Milton Roy Motor-Driven Controlled Volume Pumps? What materials do they pump? How and where are they used? What different designs and models are available?

The answers to these questions and many more can be found in Bulletin No. 251. This illustrated, 24-page, 2-color bulletin is full of important details. Here is a preview of some of the subjects which are discussed:

- a description of various Milton Roy Motor-Driven Controlled Volume Pumps—the Simplex, Duplex, Constametric, "Titronic," and "miniPump."
- an explanation of the exclusive Milton Roy Liquid End Step-Valve design. This information is useful because it describes the "how" and "why" of this unique non-clogging, self-cleaning liquid end.
- a description of pump capacity regulation by *plunger stroke* adjustment, including screw adjustment, micro adjustment, motorized micro adjustment.
- details on pump capacity regulation by *plunger speed* adjustment, including speedranger adjustment, "Thymotrol" adjustment, Link Belt P.I.V. adjustment.
- data on where Milton Roy Motor-Driven Controlled Volume Pumps can be used.
- capacity-pressure selection tables are included.

If your operations call for pumping liquids in accurately measured volume in amounts as low as 3 milliliters per hour or as high as 50 gallons per minute, we're sure Bulletin No. 251 will be of value to you. For your free copy, write the Milton Roy representative listed in your local classified telephone directory. Or, write directly to us.

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CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

methods. A test method of this type makes it easy to follow changes in the activities of a catalyst used in commercial operations. It also serves as a valuable tool in research on catalyst preparations. It is true, however, that foreign cations capable of base exchange with the ammonium ions will interfere with the procedure.

A Simple Helical Packing for Laboratory Fractionating Columns.

F. B. Shorland (Fats Research Laboratory, Department of Scientific and Industrial Research, Willington, New Zealand), *Jour. of Applied Chem.* **2** (1952), pp. 438-40.

A laboratory fractionating column is described that comprises a closely coiled spring wound as a single layer on a central core of sealed Pyrex tubing, and with its adjacent turns separated by one or more turns of a loosely coiled spring. In order to secure a good fit between the packing and the outer Pyrex tube of the column the latter is shrunk onto the packing by applying vacuum and gently heating the outer jacket tube. The holdup of the packing is low, and the pressure drop of the column is also low. The number of plates was found to vary from 30 to about 50, in columns approximately 50 cm. long. The author describes other types of packings used in fractionating columns and compares the new packing with some of those used in the past.

"Symposium on Analytical Methods for Butadiene."

Analytical Chemistry **24** (1952), pp. 1080-94.

Seven papers are included in the symposium on Analytical Methods in the Manufacture and Utilization of Butadiene, sponsored by Technical Committee H, American Society for Testing Materials Committee D-2, and the Synthetic Rubber Division of the Reconstruction Finance Corporation. Subjects covered were: Determination of Individual Acetylenes in Butadiene and in C_4 Hydrocarbon Fractions, the Manganous Hydroxide Method of Test for Oxygen in Butadiene Vapors, the Determination of Light Hydrocarbons in Water, Differential Refractometer for Process Control, Ultraviolet Spectrophotometric Method for Determining p-tert-Butyl Catechol, Determination of Acetylenes in Specification Butadiene, and Routine Determination of C_4 Hydrocarbons in Furfural or Absorber Oil.

Indiana Standard Announces Undergraduate Fellowships

Standard Oil Company (Indiana) has established 14 undergraduate scholarships in liberal arts colleges in the midwestern states in which it operates, to further the training of technical personnel.

Each of the colleges will be awarded $1000 this summer. The scholarships of $500 will be awarded to outstanding students in chemistry. The additional $500 will go to the college department of chemistry to assist in providing books, equipment or other assets that will help attract and train students in chemistry.

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[New Patents Affecting Petroleum Refining]

Dr. Heinz Heinemann
Compiled from U. S. Official Gazette Sept. 2, 9, 16 and 23, 1952

Refining and Regeneration Of Treating Agents—

Liquid-Liquid Extraction Process and Tower. J. R. Casler and C. C. Nelson to Standard Oil Development Company.

In the countercurrent contacting of two liquids at least partially immiscible in one another and having different densities, particularly in the selective solvent extraction of petroleum oils, a circular contacting plate is used which has five plane surfaces arranged in horizontal and vertical planes to form three steps for carrying out the extracting treatment in three successive steps. U.S.P. 2,609,276.

Contacting of Immiscible Liquids. T. L. McNamara to Phillips Petroleum Company.

Two immiscible liquids of different specific gravities are contacted, for example in the solvent extraction of hydrocarbon oils, in a vertical column provided with a plurality of vertically spaced horizontal trays each of which is equipped with aspirators adapted to jet the lighter liquid from the space below the tray into the space above it and to suck the heavier liquid on the tray into intimate admixture therewith. U.S.P. 2,609,277.

Azeo-Extractive Distillation. J. H. Boyd to Phillips Petroleum Company.

A mixture of cyclopentane and neohexane is distilled in the presence of methyl formate to form an azeotrope with the neohexane and in the presence of furfural to depress the volatility of the cyclopentane. A mixture of neohexane and methyl formate is recovered as overhead product. Neohexane is recovered from this mixture by contacting it with furfural. U.S.P. 2,609,333.

Adsorption Process and Apparatus. C. H. O. Berg to Union Oil Company of California.

In the separation of gaseous mixtures by selective adsorption, a compact moving bed of granular adsorbent is circulated through a column and divided into two streams which are contacted separately with streams of feed gas. The enriched streams of adsorbent are then combined for desorption by a stripping gas, while the unadsorbed gas is removed. The lean adsorbent is reactivated and recircled to the adsorption zone suspended in a portion of the unadsorbed gas. U.S.P. 2,609,887.

Extractive Distillation Process. W. M. Drout, Jr., to Standard Oil Development Company.

A specific process of extractive distillation is claimed for the separation of two or more components of a mixture, such as hydrocarbon isomers from one another, paraffins from olefins, and the like. U.S.P. 2,610,141.

Continuous Adsorption Process. L. W. Pollock to Phillips Petroleum Company.

For separating a mixture of low-boiling hydrocarbon gases, a stream of this mixture is countercurrently contacted with a gravitating column of granular activated charcoal to selectively adsorb the higher mole weight hydrocarbon. The enriched charcoal is further treated to recover desorbed hydrocarbon and to recycle recovered charcoal from the desorbing operation. U.S.P. 2,610,703.

Separation of Ethane and Ethylene by Extractive Distillation. J. A. Patterson to Standard Oil Development Company.

A gaseous mixture containing hydrogen, methane, ethylene, and ethane is subjected to extractive distillation at a pressure of 200 to 300 psi, in the presence of acetone or furfural, or water solutions thereof. Ethylene and ethane are absorbed and separated as bottoms while hydrogen and methane are removed as the distillate. U.S.P. 2,610,704.

Extraction Process. C. L. Read to Standard Oil Development Company.

In the extraction of petroleum crude oil and the like with phenol, an amount of 0.0001 to 0.3 percent by volume of silicone polymer oil, such as dimethyl silicone polymer, is added. U.S.P. 2,610,942.

Recovery of Alcohols from Hydrocarbon Oils. S. G. Gallo to Standard Oil Development Company.

Oil-soluble aliphatic alcohols are separated from their solution in hydrocarbons by extraction with an aqueous alcohol solvent. The extract phase formed is contacted with a low boiling hydrocarbon to separate the alcohols from the aqueous solvent. U.S.P. 2,610,977.

Process for Removing Metals from Crude Petroleum Oils. E. A. Coons to Sinclair Refining Company.

Crude petroleum oils containing metal compounds are intimately mixed with fluorosulfonic acid to form metal fluorosulfonates which are removed. The thus pretreated oil is used as a charging stock in catalytic cracking. U.S.P. 2,611,735.

Conversion, Cracking and Reforming—

Apparatus for Handling Finely Divided Solid Materials. C. E. Kleiber to Standard Oil Development Company.

An apparatus is claimed for discharging a high density mass of finely divided solid material into a flowing stream of a fluid material, for example a finely divided catalyst to be employed in the cracking of hydrocarbons. U.S.P. 2,609,248.

Conversion of Carbonaceous Materials into a Fuel Gas. J. C. Kalbach to Hydrocarbon Research, Inc.

Fuel gas of high heating value is produced from solid carbonaceous material containing volatilizable constituents, such as oil shale, lignite, etc., by simultaneous hydrogenation and antogenous carbonization of the charge material in comminuted form in a dense phase fluidized bed in contact with a stream of hydrogen. Details are claimed. U.S.P. 2,609,283.

Pyrolytic Conversion of Oil Shale. L. K. Cheney to Sinclair Refining Company.

Oil shale is ground with water to form a slurry. The slurry is treated with hydrochloric acid, hydrofluoric acid, or hydrogen fluoride in an amount of 0.5-6 percent by weight of the shale to thereby catalytically activate inorganic constituents of the oil shale. The oil shale is then filtered and dried and subjected to a retorting operation to produce shale oil therefrom. U.S.P. 2,609,331.

Hydrocarbon Conversion. V. O. Bowles and A. H. Schutte to The Lummus Company.

In a continuous, cyclic method of converting heavy hydrocarbons into coke and lighter hydrocarbons, the coke is obtained in a calcined form of dense nature and contains substantially no ash. The heavy-hydrocarbon charge is spread in liquid phase on the particles of a moving column of a compact, unagitated, free-flowing continuous bed of heated coke particles at points within the column whereby the charge is converted into solid dry coke adhering to the coke particles of the bed, and vaporous lighter hydrocarbons which are removed. Further details are claimed. U.S.P. 2,609,332.

Catalytic Apparatus. R. K. Hunter to Universal Oil Products Company.

The construction is claimed of an apparatus for introducing subdivided solid particles into a contacting chamber. The gravity flow of the particles to the chamber is controlled without the use of mechanically operated means. For this purpose, a regulated fluid stream is passed angularly upwardly around the accumulation of particles. U.S.P. 2,610,909.

Catalyst Support. R. E. Heffner to Phillips Petroleum Company.

A contact chamber is claimed for the catalytic conversion of hydrocarbons and the like, which chamber is provided with a support for the catalyst arranged in a tube in which the ratio of the area of the open space to the cross sectional area of the tube is relatively large. U.S.P. 2,611,684.

Fluid Distributor for Vessels. R. J. Yoder to Standard Oil Development Company.

An apparatus for contacting vapors with fluidized, finely divided solid particles is provided with a series of truncated concentric cones arranged in the bottom of the reaction vessel to cause even distribution of the entering fluid into the relatively large cross-sectional vessel. U.S.P. 2,611,685.

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England — J. Blakeborough & Sons, Ltd., Brighouse, Yorks. • *France* — Premafrance, Paris

Reforming Process and Catalyst Therefor. V. Haensel to Universal Oil Products Company.

A gasoline fraction is contacted at reforming conditions with a catalyst prepared by combining 0.1 to 8 percent by weight of a halogen with alumina, forming the product into particles of uniform size and shape, calcining them and commingling with them a platinum compound-ammonium hydroxide solution in an amount to obtain a final catalyst of 0.01 to 1 percent platinum content. The composite is finally heated to a temperature of 500 to 1000 F. This method of manufacturing the catalyst is also claimed as such. U.S.P. 2,611,736.

Process for the Preparation of Hydrocarbon Cracking Stock for Catalytic Cracking. V. A. Johnson to Sinclair Refining Company.

Catalytic charge stock is continuously prepared from residual stock having components which tend to crack and form coke upon heating to a high temperature and from distillate stock. The residual stock is separately preheated to about 800 F. and flashed to knock out tar and asphaltic matter. The remaining vapors of a temperature of about 800 F. are combined with vapors of the distillate stock heated to a temperature above 1050 F., and the combined vapor stream is quickly heated to above 1080 F., whereupon the superheated vapor stream is conducted to a catalytic cracking system. U.S.P. 2,611,737.

Alkylation—

Alkylation of Thiophene. W. J. Zimmerschied and R. C. Arnold to Standard Oil Company (Indiana).

For the preparation of alpha alkyl thiophenes, a dispersion of an alkali metal in liquid ammonia is mixed with thiophene or an alkyl homolog thereof having at least one unsubstituted alpha carbon atom. An alkylating iodide, bromide, chloride, or sulfate with 1-16 C atoms is introduced into the mixture at a temperature of —50 to +50 C. The resulting alpha alkyl thiophene is recovered. U.S.P. 2,609,375.

Polymerization—

Copolymers of a Polyene, an Alkene, and an Olefinically Unsaturated Aromatic Hydrocarbon. W. J. Sparks and D. W. Young to Standard Oil Development Company.

High mole weight rubbery copolymers with low iodine number are obtained from certain proportions of isobutylene, styrene, and a polyene with 4-8 C atoms or vinyl acetylene at a temperature below —50 C. in the presence of an inert solvent and a Friedel-Crafts catalyst dissolved in an alkyl halide with 1-2 C atoms promoted by an ether. U.S.P. 2,609,359.

Emulsion Polymerization in Systems Containing an Organic Hydroperoxide. C. F. Fryling and C. A. Uraneck to Phillps Petroleum Company.

In the emulsion copolymerization of 1.3-butadiene and styrene at a temperature of 0 to —40 C. in the presence of ferrous sulfate and sodium pyrophosphate, phenyl (dimethyl) hydroperoxymethane is added. U.S.P. 2,609,362.

Copolymerization of Divinyl Benzene and Isobutylene. L. M. Welch to Standard Oil Development Company.

A major proportion of isobutylene is copolymerized with a small proportion of a divinyl aromatic compound having no more than 2 C atoms present in each vinyl substituent, and with butene-1 at a temperature of —10 to —164 C. in the presence of a Friedel-Crafts metal halide catalyst dissolved in a low freezing, non-complex-forming solvent. U.S.P. 2,609,363.

Use of Methanol in Emulsion Polymerization. C. F. Fryling and J. E. Troyan to Phillips Petroleum Company.

A conjugated diene is polymerized at a temperature of 0 to —40 C. while dispersed in an aqueous medium containing 10-50 percent methanol and at least enough that the freezing point of the medium is lower than the polymerization temperature. The emulsion formed by this medium shall be of the oil-in-water type. An organic hydroperoxide and an activator solution are added. The resulting polymer latex remains fluid at the indicated temperature. U.S.P. 2,609,366.

Styrene Copolymer Mixtures. W. H. Smyers and D. W. Young to The Dow Chemical Company.

In 70 to 95 parts of styrene are dis-

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solved 5 to 30 parts of high mole weight styrene-isobutylene copolymer of certain characteristics. The mixture is subjected to a polymerizing reaction in the presence of benzoyl peroxide. U.S.P. 2,610,962.

Copolymerization of 1,3-Butadienes with Dialkyl Methylenemalonates. R. H. Ewart and W. V. Smith to U. S. Rubber Company.

A mixture of 1,3-butadienes and diesters of methylenemalonic acid is emulsion polymerized in the presence of an iron or cobalt salt activator at a temperature of —50 to +30 C. U.S.P. 2,610,964.

Homogeneous Polymerization of Vinylidene Compounds Using a Hydroperoxide Catalyst and a Basic Nitrogen Compound. E. J. Vandenberg to Hercules Power Company.

A monomer containing the $CH_2{=}C<$ group is polymerized by a peroxide catalyst in the presence of alpha, alpha-dialkylaryl hydroperoxide and a certain type of basic nitrogen compound, e. g. ammonia. U.S.P. 2,610,965.

Copolymers of Oxidized Isobutylene Fractions with Hydrocarbons. E. M. Geiser and A. J. deRosset to Universal Oil Products Company.

A conjugated diolefin, a vinyl aromatic hydrocarbon, and a fraction of liquids boiling above 140 C. and resulting from the partial oxidation of aliphatic monoolefinic hydrocarbons of not more than 5 C atoms, are reacted with another at a temperature of —50 to +20 C. in the presence of a Friedel-Crafts catalyst. An elastomeric resin is produced. U.S.P. 2,611,764.

Hydrocarbon Synthesis—

Production of Hydrocarbon Synthesis Gas. B. J. Mayland to Phillips Petroleum Company.

A Fischer-Tropsch and Oxo synthesis gas is prepared from natural gas by partial oxidation. The gas thus obtained is passed through a porous partition through which the hydrogen diffuses substantially more rapidly than the carbon monoxide, so that it becomes possible to change the ratio of H_2 to CO in this gas and to form a gas mixture richer in hydrogen than the synthesis gas first obtained, and a mixture substantially poorer in hydrogen. U.S.P. 2,609,382.

Production of Ammonia. W. Gray to Phillips Petroleum Company.

Natural gas is reformed by reaction with steam to produce a gas containing hydrogen and carbon monoxide and residual amounts of methane. Air is admixed with this gas and reacted to remove the oxygen of this air by combustion. The resulting gas is freed of carbon monoxide and carbon dioxide. The remaining gas rich in hydrogen and nitrogen is employed for catalytically synthesizing ammonia. U.S.P. 2,610,106.

Synthesis of Hydrocarbons. A. Clark to Phillips Petroleum Company.

A mixture of one to three volumes of

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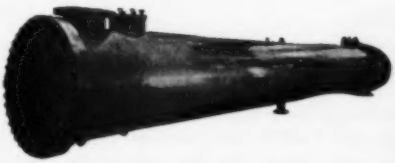

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hydrogen and one volume of carbon monoxide is treated in a Fischer-Tropsch synthesis with a cobalt containing catalyst until not more than 70 percent of carbon monoxide are converted. After separation of C_5+ products from the reaction effluent, the residual gas is mixed with such an amount of carbon monoxide that the proportion thereof in the gas mixture is raised to the value present in the feed gas. This gas mixture is then subjected to a second synthesis treatment under the same conditions as those maintained in the first step. U.S.P. 2,610,200.

Process for the Synthesis of Hydrocarbons from Carbon Monoxide and Hydrogen with an Iron Type Catalyst. J. J. Owen and S. D. Sumerford to Standard Oil Development Company.

A mixture of hydrogen and carbon monoxide in proportions of 1:1 to 2:1 is passed under specific conditions at a temperature of 625 to 725 F. and a pressure of 400 to 600 psi, over a catalyst consisting of metallic iron and iron oxides promoted by a potassium compound. A product rich in high mole weight hydrocarbons is obtained. U.S.P. 2,610,975.

Hydrocarbon Synthesis. H. Z Martin and I. Mayer to Standard Oil Development Company.

In a Fischer-Tropsch synthesis in the presence of a dense, turbulent fluidized catalyst, beds of this catalyst are maintained in a plurality of separately confined reaction zones. The catalyst is passed in series through these zones, while a carbon monoxide/hydrogen gas mixture is supplied to each of them in parallel flow. Spent catalyst is withdrawn from the last zone, regenerated, and recycled to the first zone. U.S.P 2,610,976.

Fuel Oils, Heavy Oils And Waxes—

Turbojet Fuel. K. G. Morris and R. A. Van Sweringen, Jr., to Standard Oil Development Company.

A turbojet fuel consists of a liquid hydrocarbon composition containing at least 50 percent by volume of aromatic hydrocarbons and 0.1-5 percent of cumene hydroperoxide. The oxygen required for the combustion of the fuel is supplied from air. U.S.P. 2,609,279.

Moisture Control of Solidified Fuel. K. A. Fischer and O. F. Hecht to the U. S. Secretary of the Army.

A stable solidified hydrocarbon body comprises a dispersion of a liquid hydrocarbon in a gelled dispersant phase comprising essentially a hydrocarbon-insoluble, water-insoluble calcium complex and a water-soluble hygroscopic polyhydric alcohol or ether of a polyhydric alcohol as a stabilizer. U.S.P. 2,610,113.

Solidification of Liquid Fuel. K. A. Fischer and O. F. Hecht to the U. S. Secretary of the Army.

Liquid hydrocarbons are emulsified in an aqueous solution of a water-soluble polymeric monovalent alkali metal or ammonium salt characterized by repeating $-CH_2CH<$ groups. The liquid dispersant phase obtained is reacted with a chloride, nitrate, or sulfate of an alkaline earth metal to convert the liquid phase into a water-insoluble, hydrocarbon-insoluble solid alkaline earth complex including the hydrocarbons in gel form. U.S.P. 2,610,114.

Noncorrosive Oil Compositions. J. H. Putman, J. Scott, and D. W. Ervine to Standard Oil Development Company.

A mineral base oil contains 0.05-5 percent by weight of sodium benzonate and 0.02-20 percent of an oil soluble metal sulfonate. The benzonate is effective as an anti-corrosion agent, while the second additive works as a solubilizer for the first. U.S.P. 2,610,151.

Rust Inhibiting Composition. M. P. Kleinholz to Sinclair Refining Company.

A mineral oil, wax or jelly derived therefrom contains 1 to 2 percent of calcium mahogany sulfonate and 0.5 to 1 percent of a certain product of partial self-esterification of alpha-hydroxy lauric acid. The composition has rust-inhibiting properties. U.S.P. 2,610,919.

Solvent Fractionation of Wax-Containing Mixtures. E. W. Clarke to The Atlantic Refining Company.

Details are claimed of a process for

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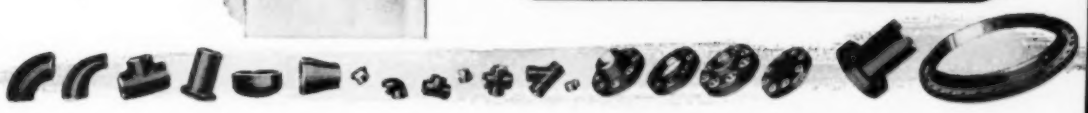

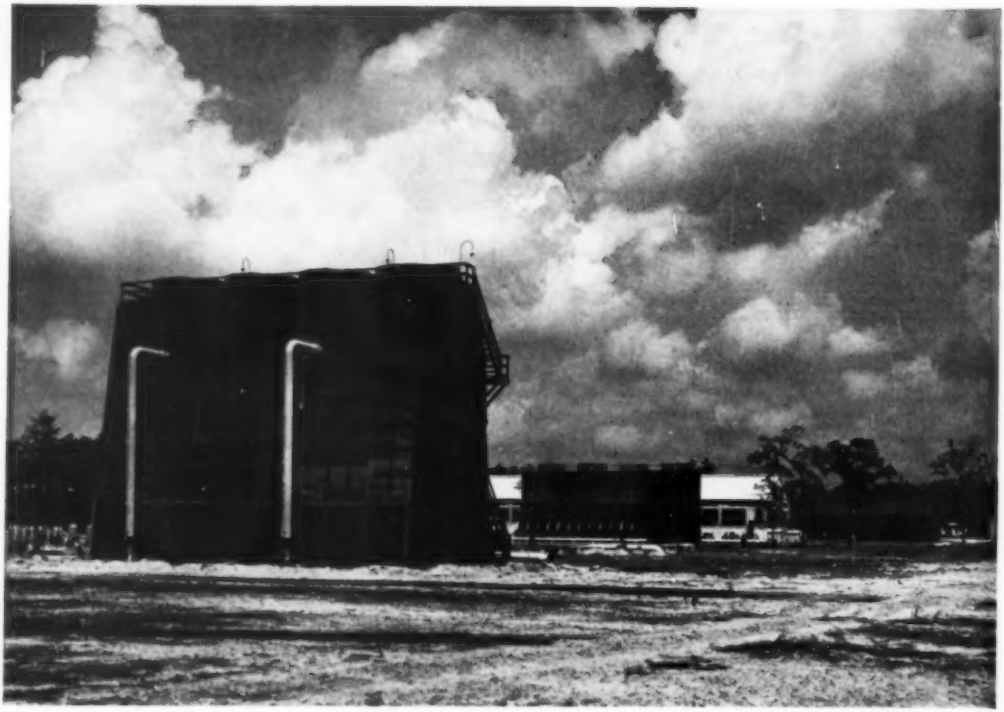

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separating hydrocarbon wax containing mixtures into fractions of higher and lower melting point. An extracting solvent is used together with solvent additives to form two immiscible liquid phases of which the one contains the higher melting wax and the other the lower melting wax. U.S.P. 2,610,943.

Lithium Soap Grease Containing Basic Alkaline Earth Metal Sulfonate. G. W. Eckert to The Texas Company.

A lubricating grease contains certain amounts of mineral lubricating oil, an aliphatic diester of sebacic, azelaic or adipic acid, lithium soap, preferably formed from a mixture of hydrogenated castor oil and stearic acid, and an alkaline earth metal salt of a sulfonated hydrocarbon. U.S.P. 2,610,946.

Lubricating Grease and Process of Manufacture. A. J. Morway to Standard Oil Development Company.

Details are claimed of a process for making a stable high temperature lubricating grease from an aromatic type mineral base lubricating oil, a C_{12}-C_{18} fatty acid, a certain type of aldehyde, and an alkali metal or alkaline earth metal base in certain proportions. U.S.P. 2,610,947.

Lubricating Compositions. A. J. Morway and W. C. Howell, Jr., to Standard Oil Development Company.

A lubricating mineral oil contains dissolved a blend of a copolymer of styrene and isobutylene and a synthetic oil of special viscosity obtained in particular manner in an Oxo process of treating monoolefins with carbon monoxide and hydrogen. U.S.P. 2,610,948.

Chemical Manufacture. J. W. Nelson to Sinclair Refining Company.

A mixture of high mole weight wax acids is produced by complete oxidation of microcrystalline petroleum wax having 34 to 55 C atoms. The product is characterized by extreme water insolubility and a saponification number less than 200. U.S.P. 2,610,974.

Wax Production Process. W. P. Ridenour to Gulf Research & Development Company.

Details are claimed of a process for preparing a mixture of paraffin waxes with high melting point and high tensile strength from a foots oil discard by solvent dewaxing. U.S.P. 2,611,734.

Lubricating Composition. E. M. Kipp to Aluminum Company of America.

A hydrocarbon lubricating oil contains a minor amount of a body consisting of animal or vegetable oil or fat and boron fluoride. Instead of the oil or fat, a fatty acid with 4 to 21 C atoms, esters of such acids with mono- and polyhydric alcohols, unmodified alcohols with at least 3 C atoms, alcohol ethers, ethers and various types of organic amines, polyamines, or amides may be used. The additives impart to the lubricant extreme pressure characteristics superior to those obtained by the corresponding organic additives without the addition of boron fluoride. U.S.P. 2,611,742-6.

Petrochemicals—

Oxidation of Hydrocarbons. C. F. Dougherty, Jr., and C. C. Chapman to Phillips Petroleum Company.

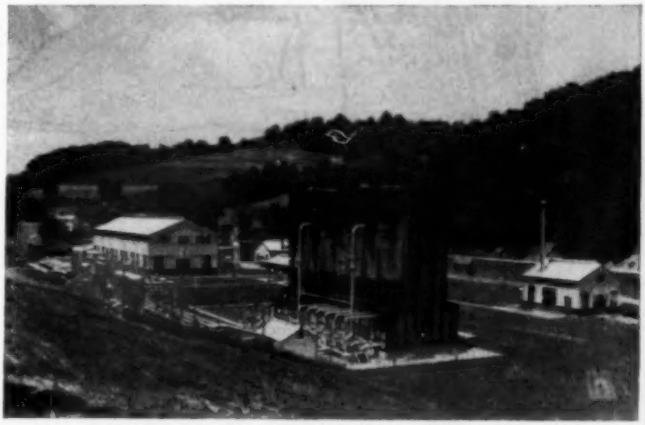
Cycloalkanols and cycloalkanones are produced by reacting a cycloalkane hydroperoxide with a stoichiometric excess of a cycloalkane at a temperature of 160-260 C., a pressure of 50-1000 psi., and a reaction time of 10-200 minutes. U.S.P. 2,609,395.

Modified Weak-Acid Isopropanol Process. E. H. Amick, Jr., to Standard Oil Development Company.

Propylene is absorbed in H_2SO_4 of 60-70 percent (by weight) concentration. A resulting acid extract of 0.6-1.5 moles of propylene per mole of H_2SO_4 is passed undiluted to a stripping zone. A hydration product distillate comprising 3-20 percent of the propylene in the extract is removed from this zone. Isopropanol is recovered from the distillate. The remaining acid extract of decreased saturation and increased acid strength is diluted to restore an acid of original strength which is recycled. U.S.P. 2,609,400.

Nitration of Saturated Aliphatic Hydrocarbons. H. B. Hass and L. G. Alexander to Purdue Research Foundation.

Saturated aliphatic hydrocarbons with 1-4 C atoms are contacted at elevated temperatures with oxygen and nitric acid or nitrogen dioxide for a period of time sufficient to permit substantial nitration of the paraffin, but not substantial oxidation of nitric oxide to nitrogen dioxide. The mole ratio of hydrocarbon



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to nitric acid employed shall be in the range of 8:1 to 25:1. Nitro alkanes and oxidation products of paraffins are produced. U.S.P. 2,609,401.

Process of Manufacturing Chlorinated Hydrocarbons. L. Vanharen to Solvay & Cie, Brussels.

Acetylene, chlorine gas and trichloroethylene are simultaneously introduced in special proportions into a zone filled with a mixture of tetrachloroethane and pentachloroethane in the liquid phase. By additive chlorination of both acetylene and trichloroethylene, tetrachloroethane and pentachloroethane are formed. These mixed products are subjected to dehydrochlorination, whereby a mixture of trichloroethylene and perchloroethylene is obtained which is separated. A portion of the separated trichloroethylene is returned to the first reaction zone. U.S.P. 2,610,215.

Production of Thiols and Thioethers. G. H. Short to Phillips Petroleum Company.

Olefins with at least 8 C atoms are contacted at 100 to 400 F. with a molar excess of a compound of the formula RSH, wherein R is H or an alkyl radical, in the presence of acid activated montmorillonite of special characteristics. Thiols and thioethers are produced. U.S.P. 2,610,981.

Catalyst Preparation, Activation, And Regeneration—

Regeneration of a Fixed-Bed Fischer-Tropsch Catalyst. J. C. Easly and H. L. Kellner to Gulf Research and Development Company.

Through a fixed bed of contaminated Fischer-Tropsch catalyst, a mixture of an inert gas and air or the like is passed at an inlet temperature of 650 to 850 F. The maximum temperature attained in the bed is limited by controlling the ratio of inert gas to oxygen and the rate of flow of the gaseous mixture to maintain a temperature difference between the inlet temperature of the mixture and the maximum temperature of the catalyst bed of less than 300 F. U.S.P. 2,609,345.

Process for Separation of Partly Dried Gel Particles. P. B. Weisz to Socony-Vacuum Oil Company, Inc.

Hydrogel particles of substantially uniform dimension are placed on a screen of mesh size such that gel particles resulting upon complete shrinkage pass through the screen while the other particles remain on the screen. A stream of drying gas is forced upwardly through the hydrogen particles until their complete shrinkage is effected. The method can be worked continuously by moving the screen through a drying zone. U.S.P. 2,609,925.

Hydrocarbon Conversion Catalyst and Process. G. M. Webb and R. W. Moehl to Universal Oil Products Company.

A silica hydrogel is composited with a metal oxide, e.g., with magnesia or zirconia. The composite is aged before dry-

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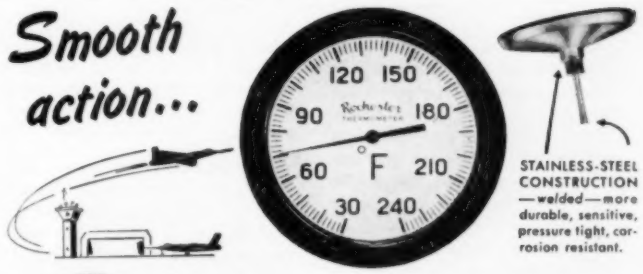
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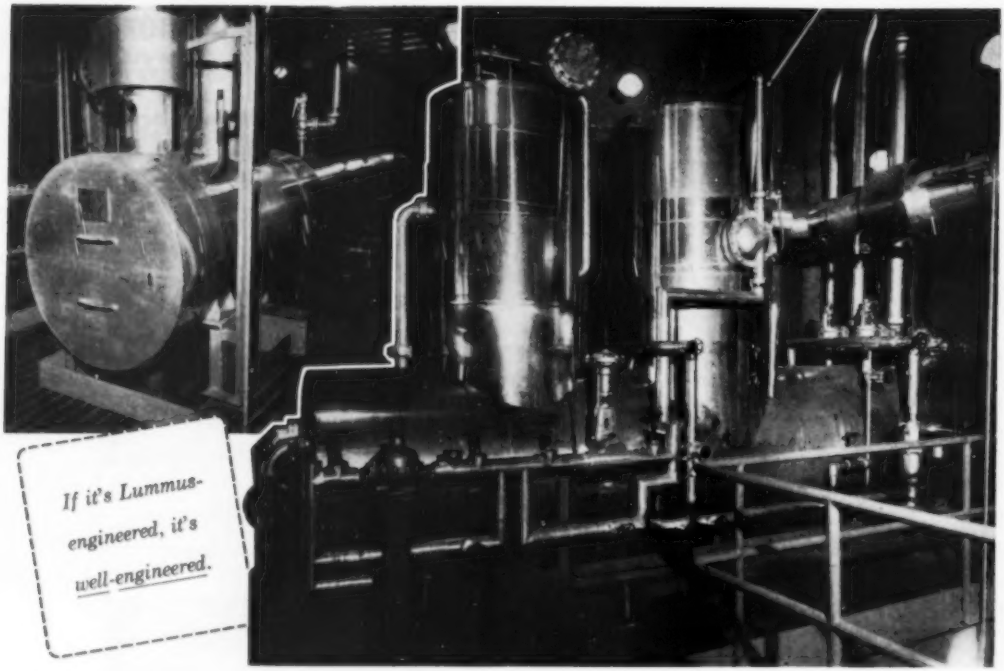

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One of the most efficient links in the chain of Metropolitan-Edison Company's steam electric plants that span lower Pennsylvania is the high-temperature, high-pressure reheat Titus Station, at Reading. And contributing in no small way to the efficiency of this modern station are two Lummus Bubble Tray Evaporators and eight Lummus Feedwater Heaters which serve two 80,000 KW turbo-generators.

Each of the 465 sq. ft. evaporators was designed to produce 15,000 lb/hr feedwater at 1.0 ppm vapor purity with a shell concentration of 2510 ppm. Recent customer-conducted informal field tests showed a vapor product well under design specifications. Solids content averaged only 0.7 ppm, with several tests pinpointing it as low as 0.6 ppm.

The eight feedwater heaters are incorporated in four stages. Six of these heaters, ranging from 2614 to 3710 sq. ft. of tube surface and operating under design pressures of 2250 pounds, are complete with desuperheating, condensing and drain cooler sections. The other two heaters, at the 21st stage, have 2220 sq. ft. of tube surface, operate under pressure of 125 pounds, and include condensing and drain cooler sections. Patented Lummus Multilok Closures on each of the heaters, assure tight, trouble-saving, cost-saving performance.

Customer satisfaction with this and previous operating installations has been translated into repeat orders. A third unit, consisting of an evaporator and four heaters, is now in fabrication for this station.

Lummus performance at Titus Station follows a pattern that's a rule where Lummus equipment is on the job. It's also another reason why Lummus will be a good name for you to remember when planning your next heat transfer project.

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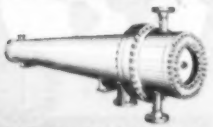

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ing at an elevated temperature and for a period of at least one hour in an ammonium salt solution having a pH below about nine. The resulting catalyst is particularly useful in the conversion of hydrocarbons. U.S.P. 2,611,738.

Preparation of an Alumina-Platinum-Combined Halogen Catalyst. V. Haensel to Universal Oil Products Company.

In the preparation of a plantinum catalyst on an alumina-halogen carrier, the platinum compound is precipitated as colloidal platinum sulfide by adding a sulfiding agent to a solution of a water soluble platinum compound in an aqueous solution containing 20 to 95 percent of a water soluble organic solvent. U.S.P. 2,611,749.

Radioactive Tracers Check Houdriflow Catalyst Flow

An unusual application of radioactive tracer technique was developed recently at Salt Refining Company's Houdriflow catalytic cracking unit at Salt Lake City, Utah. In this unit, cracking is accomplished by bringing oil vapors into contact with a solid moving bed of bead catalyst passing downward through the reactor and regenerator. Uniform flow of catalyst is necessary for maximum operating efficiency.

Engineers of the California Research Corporation conceived the idea of introducing into the unit a few pellets of catalyst impregnated with a radioactive substance. The travel of individual radioactive particles was traced by means of Geiger counters located at appropriate points along the catalytic equipment. The intensity of radiation from the particles was selected at such a value that the path and average velocity of individual radioactive particles could be plotted.

The survey proved that catalyst circulated through all parts of the Houdriflow unit with excellent uniformity.

Short Course In Corrosion Scheduled At Berkley School

A five-day short course in corrosion will be given February 2-6, 1953, at the University of California, Berkeley by the university's extension department and the departments of mechanical engineering, mineral technology and chemical engineering. The course will be given in cooperation with the National Association of Corrosion Engineers.

Speakers from industrial and governmental laboratories and academic institutions will cover basic corrosion science theory and application of corrosion mitigation measures. Scheduled, also, are numerous discussions.

NACE Announces Titles Of Papers For 1953 Meet

Titles of papers that will make up the Protective Coatings Symposium at the ninth annual meeting of the National Association of Corrosion Engineers to

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Everyone walks safely, confidently on Blaw-Knox Electroforged Steel Grating . . . the one-piece panels stay rigid and strong—without shimmy or shake—because there are no parts to work loose. Twisted cross bars provide sure footing under the most adverse conditions. For complete information, write for Bulletin 2365.
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COOLING TOWERS
Designed to meet actual—not theoretical—operating needs, the 600-GPM, forced-draft Aqua-Therm Cooling Tower shown above accomplishes in its area, 12'-6" x 20'-0" x 8'-0" high, what few towers more than twice its height can achieve. Installed at a Gulf Coast chemical plant, this tower takes ON water at 118°F and takes it OFF at 86°F—with an air wet bulb reading of 80°F. Aqua-Therm "know how"—in utilizing maximum results from the surface area potential of the ceramic saddle fill material (see left)—also reduces pumping horsepower requirements by 50% or more and eliminates almost 100% of drift.
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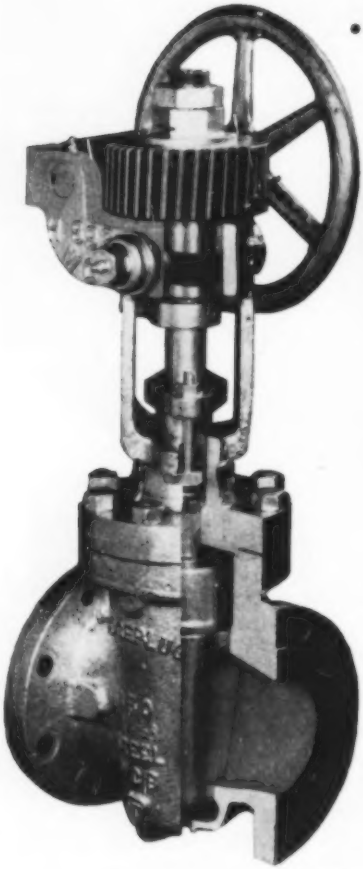

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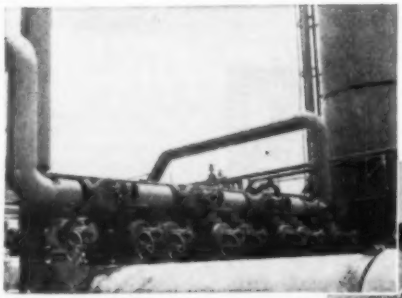
Wedgeplug Valves are Dry Plug Valves that combine the best features of a Gate Valve and a Plug Valve, and can take the place of Standard Gate Valves. They provide speed, power, quick action, and *positive* operation. May be opened and closed with a few turns of the handwheel. THE PLUG LIFTS, TURNS, AND RE-SEATS IN ONE OPERATION, by means of a patented cam action . . . Wedgeplug Valves are compact, and are of convenient height for adjustments while in the line. The dry plug eliminates need for lubrication, thus effecting worthwhile saving in lubricants and manhours. Simplicity in design, accuracy of manufacture, ease of adjustment, and positive operation at all operating temperatures and pressures assure dependable service and low maintenance cost.

Large Port Openings assure that there is minimum restrictional loss, even at low pressures. The Plug Seat is not exposed in the open position, nor in the closed position, thus preventing seat erosion and corrosion.

Wedgeplug Valves are priced to compete with conventional-type Plug Valves. Write for Wedgeplug Catalog No. 52 W.



Wedgeplug Valves are made in three types: Wrench-operated, Handwheel-operated; and, Worm Gear-operated; the latter being adaptable for operation by remote control. All sizes can be steam-jacketed.

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DRY PLUG ELIMINATES NEED FOR LUBRICATION

be held in Chicago, March 16-20, 1953, have been announced.

Included will be Investigation of Protective Coatings for High Temperature Underground Pipelines by C. R. Stauffer, Nature and Theory of Filiform Corrosion by M. VanLoo, Effects of Composition of Steel on the Performance of Organic Coatings in Atmospheric Exposure by F. L. LaQue and J. A. Boylan and Weld Seam and Weld Flux Effects on Coating Life by A. J. Liebman.

NACE also announced that its 1954 Conference and Exhibition will be held March 15-19 inclusive at Kansas City.

Indiana Standard Says No To Synthetic Fuel Plants

The chairman of the board of the second largest American oil company recently answered no to the appeal of Interior Secretary Chapman for private industry to get into the synthetic fuels business.

Secretary Chapman in his annual report told Congress that methods of producing synthetic liquid fuels, including gasoline from coal are so advanced it would be "prudent" for the petroleum industry to start building pioneer commercial plants. The secretary emphasized industry should be given government assistance to build the plants which would turn out all kinds of oil products from both coal and shale.

Dr. Robert E. Wilson of Standard Oil Company (Ind.) said the early construction of commercial plants to make liquid fuel from coal or oil shale "would be most premature."

Suggestions Mean Money To Socony-Vacuum Employes

Suggestions have been submitted by almost half of the 43,000 employes of Socony-Vacuum Oil Company, Inc., in the U. S. since the company's suggestion system went into operation four years ago. Of these, the company has adopted 703 which resulted in savings through improved methods of operation.

Suggestions adopted for which no actual or immediate savings return can be calculated, number 3963, including 1,166 aimed at improving safety.

At present, about 30 percent of all the ideas processed are being adopted by the suggestion system's award boards throughout the country. The minimum award for an idea that is adopted is $10. So far six awards have exceeded $1000, while the largest award granted to date for a single idea is $3500.

Barker Heads Promotions In Walter Kidde Department

A former chemical engineer for Kellex Corporation who took part in the design of process equipment for the K-25 Gaseous Diffusion Plant at Oak Ridge, Tenn., has been named as head of the process department of Walter Kidde Nuclear Laboratories. He is J. J. Barker, one-time design engineer for the Hydrocarbon Research Company, Inc.

In his new capacity, Barker will be responsible for process design and development work performed by Walter Kidde Nuclear Laboratories.

Four chemical engineers, K. E. Diehl, D. Mars, Dr. E. S. Roszkowski and J. F. Sheehan, were also appointed to the process department staff.

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MURRAY BD BOILER

● Available in sizes ranging up to 200,000 lbs. of steam per hour. Both fire tube and water tube—straight or bent tube designs. One, two, three or four drums.

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All EXCEL-SO Calibrating Tanks are "Guaranteed Satisfactory," are designed to conform to the A.P.I. tentative code #1101, but may be furnished with such modifications as you, the customer, may require.

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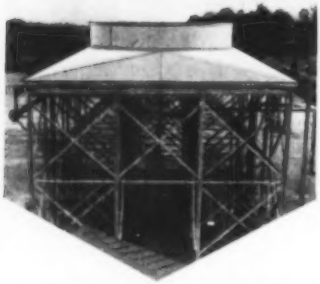
Aeromaster
FANS
are BEST for
ANY Cooling Job



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[What's New in Books]

Gas Interchangeability Report

Interchangeability of Oil Gas and Natural Gas, D. L. Nicol, Institute of Gas Technology, 17 West 34th Street, Chicago. $2.50.

When a utility changes over from manufactured to natural gas, differences in composition of the two gases require conversion and adjustment of practically all appliance burners in the service area. In the event of an emergency, the former type of manufactured gas cannot then be re-substituted.

With this in mind, the Institute of Gas Technology has taken a major interest in the manufacture of gases which are completely interchangeable with natural gas.

Present studies are concerned mainly with improving the substitutability of oil gases for natural gas through modifications of their compositions by one or more of these techniques:

a) by mixing or dilution with inerts.

b) by reduction or removal of specific aromatic hydrocarbons through scrubbing, freezing or compression, or

c) by control of severity of cracking in the production of oil gases.

The results of these studies are presented in the report.

Chemical Reactions Simplified

Maleic Anhydride Derivatives, Lawrence H. Flett and William H. Gardner, John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. $6.50.

Students and research workers interested in synthetic organic chemistry and industrial chemists faced with the problem of finding suitable chemicals to solve specific problems will find much use for this publication. Not designed as a textbook to be studied from cover to cover or in any sense an encyclopedia, it is written particularly for the busy investigator who is already overburdened by the rapidly expanding chemical literature.

Chemical Economics Award

An Annual Award for the first and second best books in the field of economics of the chemical process industries has been established by R. S. Aries and Associates for the purpose of encouraging chemists, chemical engineers, economists and chemical executives who are experts on economic aspects of the industry to put their knowledge to work.

The first prize will be a gold statuette, symbolic of chemical economics, and the second prize a similar statuette of silver. Advance royalties of $1500 will be paid to the winner of the first award, and of $500 to the winner of the second award at the time the awards are made. The first presentation will be in September, 1953. Entries may be submitted through July 1, 1953.

The winning manuscripts will be published by Chemonomics, Inc., an affiliate of R. S. Aries and Associates. In order to be eligible, a book must have a minimum length of 20,000 words and must be written especially for the contest. An entry form may be obtained from Chemonomics, 400 Madison Avenue, New York 17, N. Y.

Chemical Industry Examined

Chemical Investments, John F. Bohnfalk, Jr., Chemonimics, Inc., 400 Madison Ave., New York 17. $5.

In this analysis of the research growth and finances in the chemical industry, the author interprets the relation of research and sales growth for major end-product groups and for 20 leading companies in the field. It points out that research and development expenditures are inter-related and suggests a statistical approach which may serve as a guide post for determining research efficiency.

Rates of growth in specific areas of chemical process industries such as plastics, synthetic fibers, medicinal and agricultural chemicals are also examined in the light of research activity.

Natural Gasoline Survey

Information Circular 7645, Natural-Gasoline and Cycle Plants in the United States, January 1, 1952, Bureau of Mines, Publications Distributions Section, 4800 Forbes Street, Pittsburgh.

According to this survey of the industry, productive capacity of natural gasoline and cycle plants in the U. S., was 811,596 barrels of liquid petroleum products a day on January 1, 1952. This represents an increase in productive capacity of 163,691 barrels a day since the last survey on January 1, 1950.

Presenting capacity data on a barrel rather than a gallon basis for the first time, the Bureau's circular shows that the industry has expanded 12 percent per year during the 1950-52 period. Also given for the first time is a breakdown of capacity by-products.

Stanford Research Starts Western Resources Handbook

The first issue of the Western Resources Handbook, produced by Stanford Research Institute, was inaugurated last month with the dispatching of 150 data sheets to initial subscribers representing industry, government agencies, financial and business houses, libraries and educational institutions. The circulation will be international.

Ralph A. Krause, SRI's director of research, has announced that the Handbook is designed to serve as a basic reference source of data on all the economic and technical resources of the eleven Western states. Most statistics are given for each year for the 30-year period 1920-1950 so as "to provide an ample base for trend analysis and forecasting studies."

Carbon Monoxide Absorption

Extensive fundamental data on absorption of carbon monoxide from industrial gases by ammoniacal copper salt solutions have been reported in a series of four Russian articles published in the Journal of Chemistry (U.S.S.R.) and the Journal of Applied Chemistry (U.S.S.R.) during the years 1933 to 1942. Complete English translations of these articles have been made available by Associated Technical Services. The reported data cover a wide range of

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This is the largest of a new type of field installation for the conservation of natural gas, furnished by Maintenance Engineering Corporation. It is a completely unitized and automatic system for pressure maintenance of oil reservoirs.

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Are you now cooling hot gas oil, cracking coil tar, hot gases or other hot fluids with water?

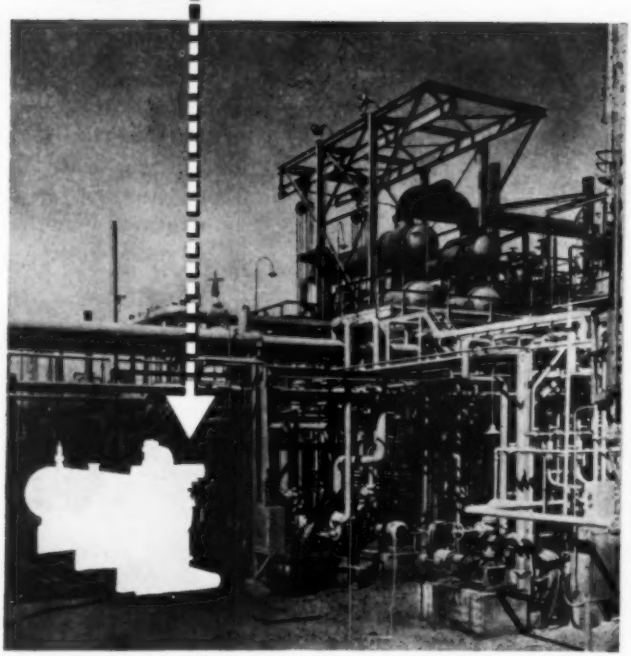
If so, investigate the G-R Waste Heat Steam Generator.

This unit uses waste heat to generate steam at boiler pressure from raw, untreated water. By doing so, it will reduce your process costs . . . your pumping costs . . . your cooling system load . . . and your boiler house steam demand.

The value of the steam produced by a G-R Steam Generator in the first year of service is usually sufficient to pay for the unit.

Various types are available to meet individual plant conditions and requirements, and special designs are available to reduce fouling of the tubes and scale accumulation.

Write for complete information on these heat-saving units that may effect important economies in your plant.



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G-R HEAT TRANSFER APPARATUS *Steam Generator*

GR 888

solutions, temperatures, pressures, and CO concentrations. Absorptive capacities, heats of solution, mechanism of complex formation, stability, and regeneration susceptibility are dealt with in detail. Absorption equations, as well as rates of CO absorption as a function of operating variables are given.

Scientific Developments

Annual Report 1951, National Bureau of Standards, Government Printing Office, Washington 25, D. C. $.50.

A summary of scientific and engineering investigations conducted by National Bureau of Standards during the fiscal year 1951, this booklet contains accounts of current activities as well as more detailed descriptions of important scientific developments. Its text provides a general description of work done in the 15 scientific and technical divisions and gives many specific examples of significant projects at NBS during the year.

Technical Literature

Over 65,000 pieces of technical literature covering a broad range of research and product engineering developments in the steel casting industry have been distributed by Steel Founders' Society of America during the last three years.

In making the announcement the Society said that as the outgrowth of its expanded informational program, interest in the industry's technological progress, products and processes has necessitated reprinting all items included in the Society's list of authoritative technical publications.

Technical Papers and Reports

Fifty-Year Index to ASTM Technical Papers and Reports, ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa. $6.

Covering American Society for Testing Materials' proceedings from 1898 through 1950, this 216-page publication provides a subject index to all the ASTM technical papers and reports dealing with materials which have appeared in ASTM publications.

It is intended to make available to the materials technologists, the researcher, the librarian and all others concerned with the fields covered, pertinent information on a particular subject.

In a condensed and usable form, the book has an author index preceding the subject listings to supply complete titles of papers and items covered.

Standard Makes Available Movie On Auto Lubrication

A new 23-minute film, "The Why of Automobile Lubrication," has been produced to instruct motorists in the care of cars. Sponsored by Standard Oil Company (Indiana), the film combines animation with live sequences and is designed to entertain and instruct both adults and young people. From it, motorists may learn what lubrication does in protecting vital parts against wear.

The 16 mm. sound, full-color motion picture will be distributed by the U. S. Bureau of Mines. It is also available from Standard's public relations department at Chicago or from advertising-public relations representatives in the company's sales field offices.

Weekends are dreary—and this Watchman appreciates comfort. Since he is *not* supervised by a DETEX GUARDSMAN Watchclock, who is to know if he steals a few hours to relax in the boss's chair?

Sometimes nobody finds out until disaster strikes. Fire, which might easily have been controlled, guts the plant. Burglars break in. Vandals cause damage. What good does it do to bawl him out *after* the terrible fact?

Play Safe with GUARDSMAN

How much wiser and safer it is to supervise your Watchman with a GUARDSMAN tape-recording watchclock. Weekends, week days or extended holiday closings—the GUARDSMAN is always on the job, making a minute-by-minute record of your Watchman's whereabouts throughout his tour. If your Watchman sleeps, shirks or skips a round, you'll know it PDQ! Why ask for trouble? Write today for free circular on the GUARDSMAN, the low-cost, quickly-liquidated protector of thousands of plants throughout the world.

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BULLETIN 152

5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; press. to 250 lbs.

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TRAPS · VALVES · FLOATS

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WELDING PAD GAGES
are integral part
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Welding Pad Gages staggered on tank for continuous visibility.

HERE is a special line of gages that weld right to the liquid containing structure, thus becoming an integral part of it. It solves problems where it is impractical for you to use a conventional type gage because of solids in suspension in a liquid, etc.

These Special Gages follow Jerguson Standard Gages in general design and materials, except for the method of attaching. The chamber of the gage consists of a bar steel pad which is welded to the vessel.

Welding Pad Gages are made in both Reflex and Transparent types . . . in all sizes of Jerguson Standard Gages. Pressure ratings are available to your specific requirements. Welding pad may be of any metal desired to withstand corrosive or other conditions.

Write for Data Unit on Welding Pad Gages for complete details. Whatever your gage problems, let Jerguson engineers assist you.

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[What Suppliers Are Doing]

Ethyl Names Naylor to New Post; Four Others Awarded Promotions

C. Fred Naylor, who has been assistant manager of Ethyl Corporation's western sales region in Los Angeles since 1950, has been promoted to the new position of manager of personnel development in that firm's sales department. He joined Ethyl in 1931 as a field representative.

Naylor

In his new assignment, Naylor will be responsible for the recruitment and selection of sales personnel and will coordinate various Ethyl sales training programs.

Monroe F. Weill, district manager at Los Angeles succeeds Naylor as assistant regional manager and is, in turn, succeeded in his post by Ellis K. Locher, formerly manager of safety. Levan R. Fleck, who has been assistant safety manager, will take over Locher's post as manager of safety.

Scull, Yarnall Named In B. F. Goodrich Company Promotions

William W. Scull, general manager of Manufacturing Services, has been named director of purchases and traffic to succeed Elmer A. Stevens and Thomas C. Yarnall has been appointed Central Division manager for the Replacement Tire Division, the B. F. Goodrich Company has announced.

Scull, who succeeds Stevens, joined the company in 1929 following his graduation from Cornell University as a mechanical engineer. Since 1947 and prior to his recent appointment, he has been general manager of manufacturing services division in Akron, Ohio.

Yarnall has been with the company for 24 years and for the present will continue to headquarter at Detroit. He is succeeding A. C. Kelly who will retire later this year. A graduate of the University of Illinois, Yarnall has served in a number of supervisory capacities. He became Detroit manager in 1948. William R. Meyer, formerly general supervisor, succeeds Yarnall as Detroit district manager.

Girdler Corporation Elected National Constructors Member

The Girdler Corporation of Louisville, Ky., engineers and designers of chemicals and processing plants, has been elected to membership in the National Constructors Association.

The NCA is an organization composed of leading firms engaged on a national basis in the design and construction of chemical plants, petroleum refineries and steel mills.

L. P. Browser, construction manager, will represent The Girdler Corporation on the NCA labor committee, and C. A. Clore, supervisor engineer, will represent the firm on the safety committee.

Wolverine Names New York Manager In Sales Department Promotion

E. W. Ervasti, who, for several years, has been the sales representative for Wolverine Tube Division, Calumet & Hecla Consolidated Copper Company, in the St. Louis area, becomes manager of industrial sales according to an announcement from that firm.

Ervasti

John M. Dumser, director of sales, said a successor to Ervasti will be named shortly. Meanwhile, Ervasti, in the new position, will make his headquarters in the company's general sales office in Detroit.

NGAA Honors W. A. Schlueter At Recent Houston Meeting

At the Natural Gasoline Association of America meeting in Houston recently, W. A. Schlueter, president of Refinery Supply Company, Tulsa, and vice president of Central Scientific Company, Chicago, was presented with a medal for helpful instrument service in the natural gasoline industry.

Schlueter's contributions include Saybolt chronometer, Saybolt viscosimeter, Tagliabue open cup flash and fire tester. Since that time he has patented many valuable items including the R. S. specific gravity gas balance, the ACME recording gravitometer, R. S. mercury purifier, R. S. dead weight tester, R. S. high-pressure consistometer, R. S. pressure hydrometer jar, and R. S. thermo plumb-bob thermometers.

Minneapolis-Honeywell Adds 34 To Industrial Division Sales

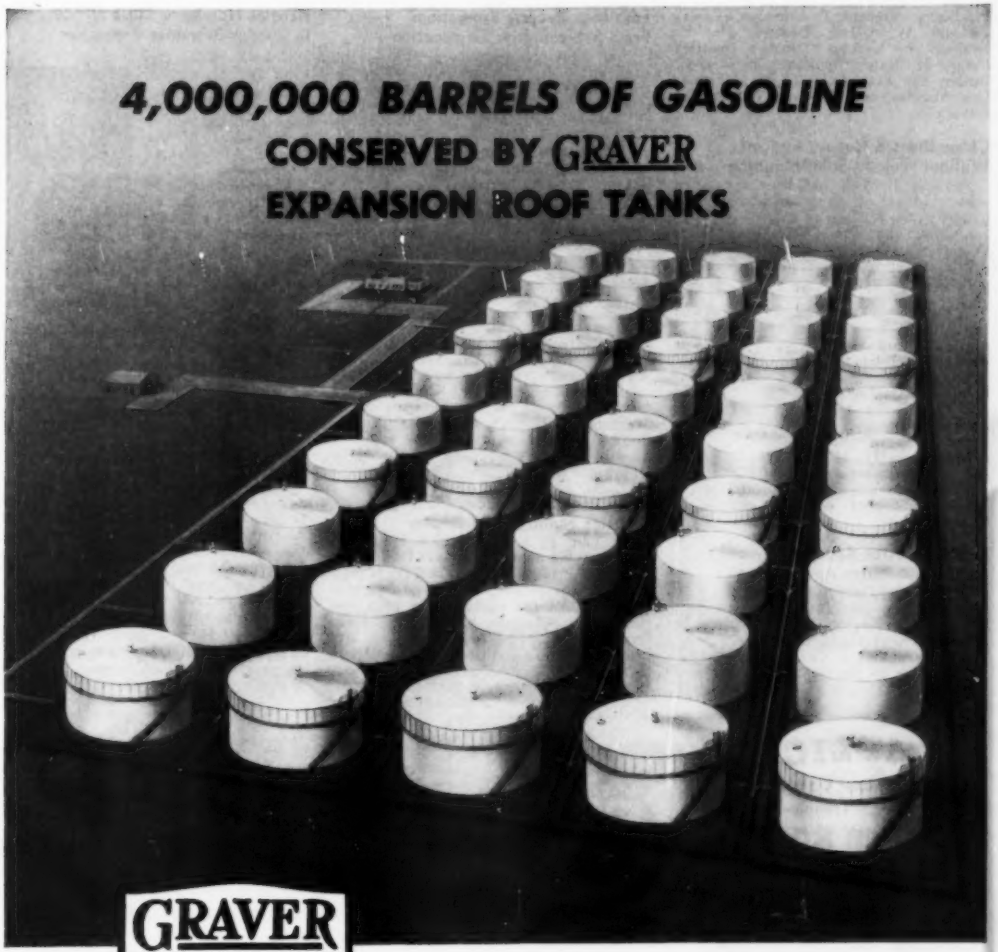
Thirty-four sales engineers were recently added to the field sales force of Minneapolis-Honeywell Regulator Company's industrial division.

The new appointees, all recent graduates from the company's industrial instrument training school in Philadelphia, mark an over-all increase of 15 per cent in the field sales group this year.

The new salesmen who will be assigned to 27 cities in 22 different states are: Edward J. Reulbach, New York; Kenneth Ryan, Ralph J. Fittipaldi and John P. Reynolds, East Orange; James E. Vanderveld, Boston; Richard E. Howard, Hartford; Joseph M. Heinold and Richard L. Kanehl, Buffalo; Don P. McAdoo, Baltimore; Albert J. Walcek, Washington; Robert H. Branch, Roanoke; Wilbur A. Dixon, Atlanta; Stephen M. Kennedy, Jacksonville; James T. Emerson, Greenville; John H. Buri, John B. Freeman and John Monsay, Philadelphia; Anthony J. Schneider, Cleveland, and Robert W. Meyer, Cincinnati.

Also, Thomas C. Farrell, Detroit; Warren G. Myers, Toledo; William B. Wells, Pittsburgh; Richard J. Bortoli and William Lyford, Chicago; Robert Lederer, Davenport; Robert G. Steel,

4,000,000 BARRELS OF GASOLINE
CONSERVED BY GRAVER
EXPANSION ROOF TANKS



GRAVER

This mammoth terminal of fifty 80,000-barrel tanks—rarely duplicated in any actual installation—represents the extraordinary record of product savings accomplished by the many Graver Expansion Roof systems throughout the country in the dozen years since the design was introduced to the petroleum industry. According to currently accepted evaporation loss factors, it is conservatively estimated that the Graver Expansion Roof has saved 168,000,000 gallons of gasoline—a gallon for every man, woman and child in the United States.

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

NEW YORK • CHICAGO • PHILADELPHIA • WASHINGTON
DETROIT • CLEVELAND • PITTSBURGH • HOUSTON
CATASAUQUA, PA. • SAND SPRINGS, OKLA. • CASPER, WYO.

St. Louis; Vincent T. Coffman, Tulsa; Thomas W. Clark, Denver; Joe C. Graham and Vernon S. Robyn, Seattle; Dwain M. Bates, Spokane; Richard C. Butler, San Francisco; Royce N. Crain, Los Angeles, and William A. Gill, Indianapolis.

Chase Brass & Copper Appoints William Weir As Sales Manager

William J. Weir has been appointed sales manager of wholesale accounts for Chase Brass & Copper Company, Inc., Waterbury, Conn., a subsidiary of Kennecott Copper Corporation.

Weir

Weir, who will specialize in the sale of brass mill products to wholesale accounts purchasing for resale, began work for Chase in the metallurgical department of the Chase-Cleveland mill. He served as condenser tube sales manager at Cleveland before being transferred to Waterbury in the same capacity.

Gram Asbestos Appointed Kaylo Distributor-Applicator

The Gram Asbestos Company, Erie, Pa., has been appointed distributor-applicator for Kaylo Heat Insulation by Owens-Illinois Glass Company. George Gram, president of Gram Asbestos, has been active in the heat insulation field since 1915.

Four Men Receive Promotions From Worthington Corporation

Four men have received promotions in the Buffalo, N. Y., plant of Worthington Corporation. The four promotions include Harold W. Whiting, assistant to the executive engineer; W. A. Scheerer, chief engineer, compressor division; W. J. Blessing, consulting engineer, and William M. Kauffman, chief engineer, engine division.

Whiting, a graduate of Case Institute of Technology, joined Worthington in 1939 after working for ten years with machinery companies in Cleveland and Erie, Pa. Scheerer was graduated from Ohio Mechanics Institute and the University of Cincinnati. He joined Worthington in 1929 as a draftsman in the compressor division. Blessing has been with the company since 1905 and has served successively as draftsman, designer, chief draftsman and in 1929 as assistant chief engineer. Kauffman was graduated from the Illinois Institute of Technology in 1926 and joined Worthington in 1932 as a research engineer and in 1945 was appointed engineer in charge of research and development.

Mills Named Philadelphia District Manager By Kinney

William B. Mills has been appointed Philadelphia district manager for Kinney Manufacturing Company, makers of high vacuum pumps and rotary liquid pumps. Mills joined the company in 1939 and served as salesman in the New England and Chicago territories. He was appointed manager of the Cleveland branch in 1947 and served in that capacity until his recent appointment.

Hensley Named to Tulsa Office In Cooper-Bessemer Expansion

Hensley

Robert E. Hensley, an engineering graduate of Oklahoma A. & M., has been assigned to the Tulsa office of the Cooper - Bessemer Corporation.

Working under the direction of Byron L. Potter, branch manager, Hensley will devote his time to engineering the installation of diesel engines, gas and air compressors for pipe lines, refineries and chemical plants in the Okla. area.

Hensley received his specialized training in engine and compressor operation at Cooper-Bessemer's headquarters plant in Mount Vernon, Ohio.

Tennessee Eastman Announces Five Changes in Sales Setup

Tennessee Eastman Company recently announced the appointment of Guy A. Kirton as assistant sales manager of the company's chemical sales division. Kirton, who has been in charge of the division's New York sales office for the past six years, will move to Kingsport, Tenn. within the next few months.

Robert H. Cannon, presently in charge of Tennessee Eastman's chemical sales offices in Chicago, takes over Kirton's position in New York, while

SIMPLICITY!
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BEAVER NO. 26-R
1 TO 2-INCH PIPE THREADER

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5 OUTSTANDING ADVANTAGES

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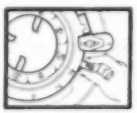

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• The new Beaver 26-R is a greatly improved and simplified successor to the "old Beaver 26," popular for 40 years. Drive ring is on top—in line with dies for easy cutting. Oversize, undersize or standard threads can be cut of uniform length. Has "radio dial" setting. Change size in 2 seconds without tools. Standard taper or electric conduit threads. One set dies. No bushings.

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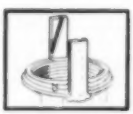
"Over 50 Years of Friendly Service"

Straight Line Pull Easier Cutting

Universal Chuck - Accurate Centering - No Bushings



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Get the facts from the 8-page Flowrite "proof" booklet, available upon request.

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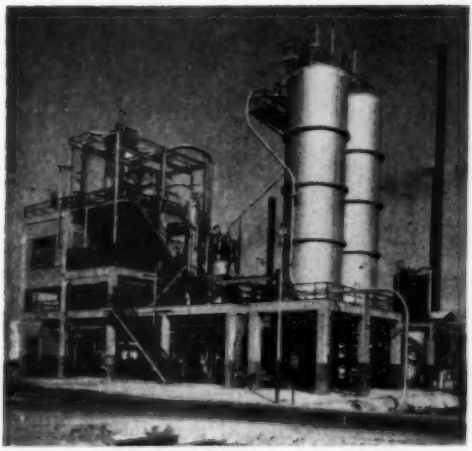

Shell's Contact Filtration Plant at Cardon Refinery, Venezuela

Refineries everywhere specify Filtrol adsorbents to refine more barrels of premium oils at lower cost.

Reasons Why Leading Refineries Everywhere Use Filtrol Adsorbents For Maximum Throughput . . .

1. **Press cake losses are reduced.**
2. **Filter capacities are increased.**
3. **Highest yields of finished oils.**

The technical service of Filtrol petroleum engineers and laboratories is at the disposal of refiners to assist them in product improvement, to decrease operating costs and increase production. Samples of Filtrol adsorbents and quotations submitted upon request.

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being replaced in Chicago by Decatur B. Campbell, Eastman Industrial Chemicals representative in Cleveland. John A. Sanders, currently on the staff of the New York office, replaces Campbell in Cleveland.

Another change brings Rawlings Hargrave from the company's chemical sales development group in Kingsport, Tenn. to the staff of the New York office.

Kolker Chemical Makes Administration Revision

A revision in the administration setup of Kolker Chemical Works, Inc., manufacturer of insecticides and pesticides and subsidiary of Diamond Alkali Company, has been announced.

With the retirement of Leon A. Kolker, founder and president of the company, J. G. Brunton, in charge of sales, and Charles H. Kolker, in charge of operations and engineering, will continue the activities of the concern. A. L. Geisinger, Diamond Alkali vice president, will coordinate the functions of the two men.

Barber-Colman Purchases Assets Of Wheelco Instruments Company

The Barber-Colman Company has announced the purchase of the principal assets of Wheelco Instruments Company of Chicago. Present plans call for current operations to continue until manufacturing facilities can be transferred to Rockford, Ill. No changes are contemplated in Wheelco's national sales and service organization. Barber-Colman Company entered the automatic control field in 1926.

Ross Joins Firm as Partner; Name Added to Sawyer-Jensen

With Donald B. Ross, formerly manager, industrial and export sales for the Kobe division of Dresser Industries in Cleveland, joining the company as a partner, the Sawyer-Jensen Company of Tulsa, Okla. has changed its name to the Sawyer-Jensen-Ross Company.

Ross

Ross will handle the promotion and sales of present products as well as working with customers to develop new equipment items for particular problems. Major emphasis will be placed on direct sales of "shortster," a side entering mixer introduced about one year ago for pipe line and refinery applications.

Joseph E. Foley Appointed Edward Advertising Manager

Edward Valves, Inc., has announced the appointment of Joseph E. Foley, Jr., as manager of sales promotion and advertising. A former d -ional advertising manager for the A -rican Brake Shoe Company and before that account executive at A. E. Aldridge Associates, Foley will be in charge of all advertising and promotional activities involved in the distribution of the company's line of cast and forged steel valves. Edward Valves is a subsidiary of the Rockwell Corporation.

[Who's Adding What]

Minneapolis-Honeywell Regulator Company—a new factory in Amsterdam, Holland to manufacture heating controls abroad for the first time in the company's history. The new plant becomes Honeywell's third manufacturing operation outside the U. S.

Metal Goods Corporation—a new plant to be built in St. Louis, made necessary by expansion of business. The company has purchased 17 acres of land to house a two-story general office, covering 50,000 square feet and modern warehouses covering 150,000 to 175,000 square feet. Grading of the property will begin immediately.

The Babcock & Wilcox Company—a district sales office in Syracuse, N. Y. to service users of the seamless and welded stainless, alloy and carbon steel tubing produced by the company's plants at Beaver Falls, Pa. and Alliance, Ohio. J. Y. McCandless is in charge.

Bridgeport Brass Company—a new warehouse in Philadelphia, built especially for carrying large stocks of brass and copper strip, rod, wire and tube products. Containing offices for the warehouse staff, the building is equipped with facilities for handling and shipping metal. David F. Snow, district sales manager, is in charge of sales and operations.

Pressed Steel Tank Company—a new division with the purchase of all the outstanding capital stock of **Downingtown Iron Works.** Downingtown retains its existing corporate structure and will

No Time Wasted!

WHEN WORKERS WEAR

STASAFE **WINDSOCKS**

The Safety Hat Liners That Need No Installation

9" length $2.64 Doz.
11" length $3.00 Doz.

Windsock is a throw-away type head covering that's easy to use. Inexpensive—it actually costs less than the *time alone* spent by a worker in installing or in removing a permanent type liner. Warm and snug-fitting Windsock puts an end to chilly winter drafts.

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SUPERIOR MANUFACTURING COMPANY
AMARILLO, TEXAS

QUESTION

To What Extent is Du Pont Responsible for Tetraethyl Lead Antiknock Compound?

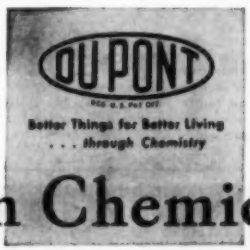
ANSWER

DU PONT is wholly responsible for developing the only safe commercial method of producing tetraethyl lead.

And, from 1923 to September 1945, Du Pont was the sole user of this method and the only manufacturer of TEL in the United States.

Today, wherever tetraethyl lead is made, the basic principles developed by Du Pont are still in use. But, in Du Pont plants only, a new and better method will soon be introduced. This too is exclusively a development of Du Pont's experience and research.

The many Du Pont services available to refiners, like its manufacturing facilities, are based on 150 years of continuous research and sound business practice. That's why more and more refiners are calling on Du Pont for technical advice and research assistance as well as marketing help and other services.



Petroleum Chemicals

E. I. DU PONT DE NEMOURS & CO., (INC.) • Petroleum Chemicals Division, Wilmington 98, Delaware

be operated as a division of Pressed Steel. No changes in management or personnel are contemplated. The products of both companies are made from steel, stainless steel, aluminum and other non-ferrous materials.

Penn Industrial Instrument Corporation—new representatives in the Texas-Oklahoma area, with the appointment of Eggelhof Engineers, Inc. Eggelhof has offices in Houston, Dallas, Corpus Christi, San Antonio, Texas, Shreveport, La., Tulsa and in Fort Worth, Texas.

Oilwell Names Smith Assistant Manager of Gulf Coast Office

Oil Well Supply division of United States Steel Company has appointed D. O. Smith assistant manager of its Gulf Coast area with headquarters located in the Mellie Esperson Building, Houston. Smith joined "Oilwell" in 1924 as a draftsman at Oil City, Penn., later was engaged in sales and management work in the Eastern division. Transferred to Dallas in 1945, Smith was made supervisor of sales personnel and training, later becoming manager of General Sales department's product development and improvement section. In 1949 he became manager of the Oklahoma district and in 1951, assistant Central Midwest area manager at Midland, Texas.

Graver Tank Transfers Office

Graver Tank & Manufacturing Company, Inc., East Chicago, Ind., has transferred its Ohio district sales office from Cincinnati to 720 Euclid Avenue, Cleveland, Ohio. The office is managed by Dwight R. Rhoades.

Wagner Electric Names Evans To Assistant Controller Post

Wagner Electric Corporation has appointed I. C. Evans as assistant controller, the position left vacant by the sudden death of C. J. Falkenrath.

Evans

Evans received a B.S. degree in Electrical Engineering from Washington University in St. Louis and is a member of Tau Beta Pi. Employed by Wagner in 1935, he advanced through the ranks and was made office manager of the company in 1947. He has served two terms as director of the St. Louis Chapter of the National Association of Cost Accountants and is presently vice president of the St. Louis Chapter of the National Office Management Association.

Quaker Rubber Corporation Opens Dallas Branch Office

Quaker Rubber Corporation, Division of H. K. Porter Company, Inc., has opened a new stock-carrying branch warehouse and sales office. The new warehouse has 5000 square feet of floor space, truck facilities and rail trackage. D. C. Hahn has been named district manager and is in charge of the office. The branch will stock the complete line of Quaker's rubber conveyor and transmission belting, hose, packing and moulded rubber products.

Pioneer Alloy Products Division Formed by National Lead Company

National Lead Company has announced the formation of the Pioneer Alloy Products division, which recently took over the manufacturing operations of the Pioneer Alloy Products Company, Inc., of Cleveland, Ohio.

Manufacturing operations of the new division will be located in Ellwood City, Pa., in a National Lead Company plant equipped as a foundry and machine shop. The division's production will consist of corrosion-resisting valves with wide application in the chemical processing and refining industries, heat-resisting and acid-resisting castings for general industrial use and chrome-nickel-steel valves formerly manufactured at National Lead Company's Fitchburg, Mass., plant.

L. J. Gambow, general manager of the Pioneer Alloy Products Company, Inc., has been named as sales manager of the new division.

Babcock & Wilcox Moves To New Eastern Offices

The Babcock & Wilcox Company, producers of steam generators and related equipment has announced the removal of their New York offices from 85 Liberty Street to new headquarters in the Chrysler Building East. The company has had its general office in the downtown district of New York for more than three quarters of a century.

American Locomotive Company Sponsors Two-Day Symposium

Nearly 100 representatives from 50 railroads in all parts of the United States and Canada attended a two-day sym-

IN WIRE-MESH PRODUCTS

LET JELLIFF DO IT!

For 70 years we've been weaving Wire Mesh. And a good part of that time we have also been making things of Wire Mesh for people who find it is cheaper, easier and generally more satisfactory to "let Jelliff do it."

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Killark

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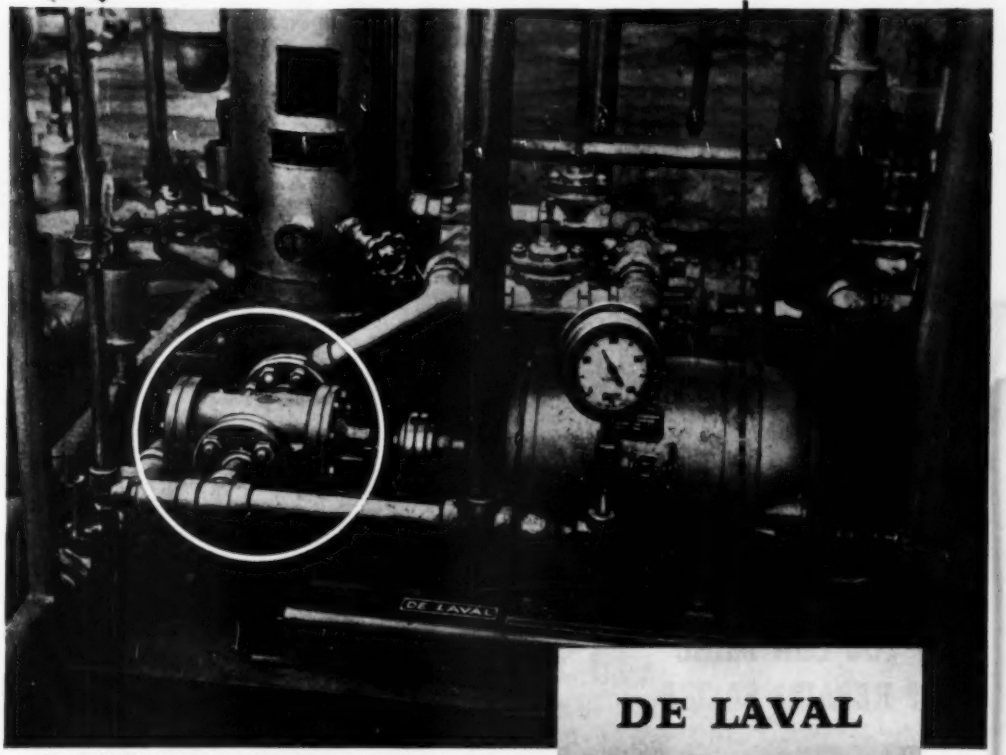
ELECTRIC MANUFACTURING COMPANY

Vandeventer and Boston Aves St. Louis 19, Mo.

Versatile pumps for refinery service



De Laval-IMO pump in service in midwest packaged gasoline plant.

DE LAVAL

IMO PUMPS

Today, De Laval-IMO rotary pumps are proving their versatility in dozens of refinery applications. These dependable pumps are being used in refineries and bulk plants to handle viscous fluids including fuel oils, heavy crude oils, lubricating oils and asphalt, as well as the lighter hydrocarbons. For example:

An eastern refinery installed an IMO to pump *viscous* oil at 550 psi. Performance was so satisfactory that three more IMO units were ordered within a few weeks.

A midwest refinery is using De Laval-IMO pumps to handle *asphalt* at 470F at 922 psi and *petrolatum* at 420F and 575 psi.

For a new tank field distribution system, another refinery has 58 direct-connected 1150 to 1750 rpm IMO pumps, handling various oils with viscosities up to 3600 SSU, capacities to 200 gpm and pressures to 150 psi.

The unique IMO design—*with only three moving parts* — assures long, trouble-free performance. IMO pumps are quiet, pulsation-free, compact and designed for direct-connected high-speed operation. Send for Bulletin LG showing wide range IMO line for capacities to 1,000 gpm at pressures to 500 psi and for capacities to 150 gpm at pressures to 1,500 psi.

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY

811 Nottingham Way, Trenton 2, New Jersey

DL 181

posium recently at Schenectady as guests of the American Locomotive Company. Subject of the symposium was the use of the spectrograph in analyzing diesel engine lubrication oil to detect and prevent serious engine trouble. Chairman of the conference was H. R. Sennstrom, Alco research and testing engineer, who gave a detailed description of Alco's own spectrographic work over the past several years.

Beckman Appoints Steinkamp Vice President, Sales Manager

William H. Steinkamp has been appointed vice president and general sales manager of Beckman Instruments, Inc., South Pasadena, Calif. Steinkamp is well known in the industrial instruments and process control fields as a result of 22 years association with the Brown Instruments division of Minneapolis Honeywell Regulator Company, where he served last as general sales manager.

Steinkamp

Steinkamp will make his headquarters at the South Pasadena plant.

A. O. Smith Signs Four Outlets

A. M. Castle & Company warehouses in San Francisco, Seattle, Los Angeles and Kansas City, Mo. have been signed as stocking outlets for the A. O. Smith Corporation safety grating.

Owens-Illinois Names Chaffee Kaylo Insulation Distributor

The H. S. Chaffee Company, Inc., in Liverpool, N. Y., has been appointed distributor-applicator for Kaylo heat insulation by the Owens-Illinois Glass Company.

The material, a chemical compound called hydrous calcium silicate, insulates effectively against temperatures ranging up to 1200 F., is lightweight and is insoluble in water.

The Chaffee Company has been active in the heat insulation field for the past ten years and handles industrial and commercial insulating materials and accessories for heat and cold applications.

Moore Products Names Valentine To Assistant Sales Head Post

Moore Products Company has appointed H. Dean Valentine assistant sales manager. Valentine came to the Moore organization in 1945, and has recently acted as sales engineer for the Philadelphia-Wilmington territory. He has been active in instrumentation since 1939 and is now vice president of the Wilmington Section ISA.

Barrett Division Names Agency

The Barrett Division, Allied Chemical & Dye Corporation, has appointed Anderson & Cairns, Inc., of New York, as advertising agency for all Barrett products, except nitrogen materials, effective March 1. The Barrett organization, established in 1854, has been advertising in national, trade and technical media for almost a half century.

Alloy Steel Products Appoints Evans as District Manager

Announcement has been made of the appointment of Herbert V. Evans, Jr., as district manager of the Alloy Steel Products Company at Wilmington, Del.

Evans

Evans, sales representative for the company at Pittsburgh, Pa. for the past five years, is a graduate of Boston College. In his new capacity, he will concentrate on direct selling activities in the Wilmington area but will also have general supervision over the Pittsburgh territory which he formerly covered.

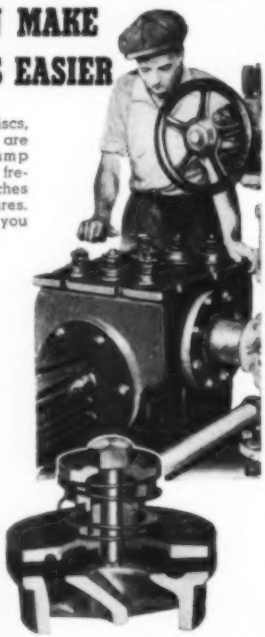
Replacing Evans as sales representative in the Pittsburgh area is E. J. Lickwar, who joined the company in January, 1952.

Babcock & Wilcox Plans New Boiler Plant in Georgia

The Babcock & Wilcox Company has purchased facilities of a former shipyard from the Brunswick Port Authority at Brunswick, Ga., and will convert it into a plant to build boilers and related equipment.

The property involved consists of about 110 acres with 250,000 square feet of floor space. It was formerly the J. A. Jones shipyard before being acquired by the Brunswick Port Authority in 1945. Rehabilitation, together with in-

HOW YOU CAN MAKE PUMP REPAIRS EASIER



Worn seats and valve discs, broken springs and stems are eliminated with Sims Pump Valves. Sims valves cure frequent pump repair headaches with exclusive design features. They're **guaranteed** to give you better pump performance.

You get longer service from seats and discs because of rotating disc that changes to a new seating-surface every time it opens. Valves can't hammer up and down.

Inclined rib seat and shock-absorber stem heads combine to permit increased speed without valve-knock. Capacity can be increased 40% and more.

Low resistance through seat reduces turbulence — gives protection against vapor binding.

Long guide gives even lift — reduces wear. Spring is protected against jamming.

Write for new catalog showing how Sims valves fit your pump and give better pump performance.

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Chemical Refining of Petroleum

By VLADIMIR A. KALICHEVSKY
Research and Development Laboratories, Socony-Vacuum Corpn.
Author of "Modern Methods of Refining Lubricating Oils"

and BERT ALLEN STAGNER, Ph.D.
Consulting and Research Chemist;
Member, American Institute of Chemical Engineers;
Formerly: Supervisor Chemical Research, Union Oil Company of California; Research Fellow, Mellon Institute of Industrial Research

American Chemical Society Monograph, No. 63
Second Edition, Revised and Enlarged

The rapid development of petroleum technology has necessitated a revision of the original volume published in 1933. The newest practice in regard to treatment with sulfuric acid, tetraethyl lead, octane rating, etc., is described in detail. The present emphasis on all phases of this vitally important subject makes this book a particularly timely one, especially since the petroleum problem today is rather one of refining capacity than of crude production. For this reason technical improvements are of the utmost importance for the pressing problems of national defense.

CHAPTERS

Prefaces
Composition of Petroleum
Treatment with Sulfuric Acid
Sulfuric Acid Sludge and Hydrogen Sulfide: Recovery and Manufacture of Sulfuric Acid
Treatment with Alkaline Reagents
Sweetening Operations. Elimination of Elemental Sulfur, and Reduction of Total Sulfur in Light Distillates
Chemical Refining of Petroleum
Refining by Adsorption
Refining with Solvents
Detonation and Antidetonants
Inhibitors of Atmospheric Oxidation of Petroleum Products. Antioxygens
Gums and Cracked Petroleum Products
Deterioration of Lubricating and Similar Oils. Additional Agents
Supplementary List of United States Patents on Petroleum Refining
Appendix. Special Tables
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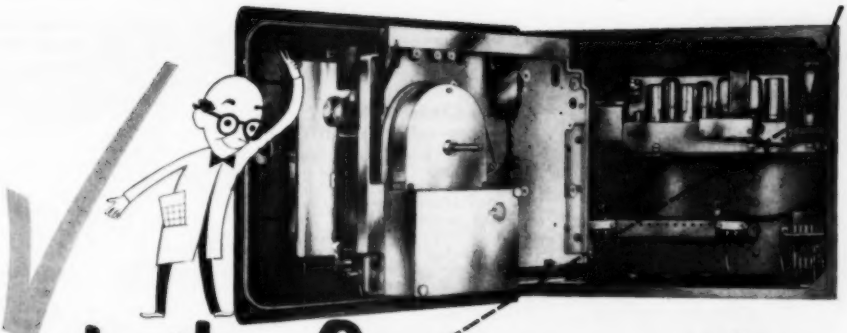

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Continuous-Balancing Electronic Recorder

The Dynamaster is a superior recording and controlling instrument because every component part is superior.

Take the Syncroverter* Switch; pictured above.

This vibrator-type d-c to a-c converter incorporates so many unique improvements that many scientists, laboratories, and manufacturers are using it in their own devices.

Among its advantages are:

- ✓ Extremely long life
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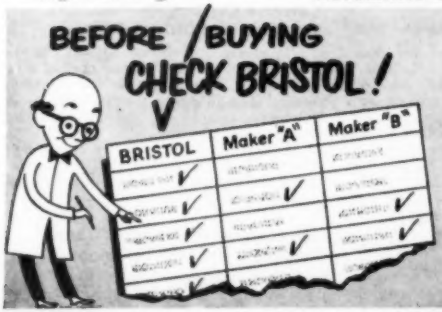

THE BRISTOL COMPANY
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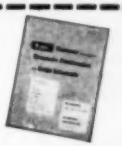

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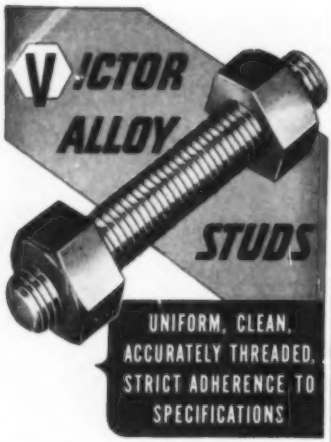
COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



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F/C PNEUMATIC TRANSMITTER

Ideal for measurement of level, pressure, specific gravity and differential pressure.

Materials available:
steel, bronze, stainless, Haveg, Hastelloy and Monel.

Non-overloading type diaphragm. Extreme accuracy. For high or low pressure.

Write for Illustrated Bulletin

INSTRUMENTS, INC.
122 N. Madison Tulsa 6, Okla.

stalling necessary new equipment, will begin immediately. This is the fourth new plant to be announced by the company in the past year.

Allis-Chalmers Names Greensward To Executive Post

J. D. Greensward was named vice president, director of manufacturing, general machinery division, Allis-Chalmers Manufacturing Company, at a recent meeting of the firm's board of directors.

When Fred Mackey recently resigned as vice president in charge of manufacturing, Greensward became director of manufacturing for the division to succeed him.

Announcement also came from the company that P. F. Bauer has been named general manager of the Norwood Works, a post previously held by Greensward, and manager of the firm's apparatus department.

Minneapolis-Honeywell Names Seven Industrial Sales Managers

Seven regional industrial sales managers have been named by Minneapolis-Honeywell Regulator Company. The regional post is new and is part of a move to give industrial field men more responsibility, the company said. Those appointed and the regions in which each will serve are: Jack E. MacConville, the southeast with headquarters in Atlanta; Alfred J. McCullough, the central region with headquarters in Cleveland; Howard L. Marston, the northwest with headquarters in Minneapolis; Robert L. Mallory, the southwest with headquarters in Dallas; Robert B. Grant, the Pacific and mountain region with headquarters in Los Angeles, and Lester W. Williams, the Pacific northwest with headquarters in Portland, Oregon.

Kline Named General Manager Of Inico's Huntington Works

E. M. Kline has been made general manager of the Huntington, W. Va., Works of The International Nickel Company, Inc., succeeding Herman M. Brown, who has elected to retire. G. K. Crosby has been appointed assistant general manager of the Works, succeeding Kline.

Kline is a native of Pennsylvania and a graduate of Penn State College. In 1923, he joined International Nickel and has served in various capacities since that time. Crosby is a native New Yorker and a Massachusetts Institute of Technology graduate. He came to International Nickel in 1936.

Named New York Distributors

Zurn Services, Inc., Erie, Pa., have appointed the John B. Foley Company as representatives for the sale of Zurn products in the eastern portion of New York state. John B. Foley and his associate, Howard Gartner, have had considerable engineering experience in various fields and are familiar with Zurn industrial products.

Hummer Named Research Director

Herbert B. Hummer has been appointed director of research for the Duametallic Corporation of Kalamazoo, Mich. Hummer was formerly with the Allis Chalmers Manufacturing Company.

Desmond to Head New Section In Ethyl's Service Division

Edwin A. Desmond, who joined Ethyl Corporation as a student engineer in 1939, has been named head of a new section in the corporation's technical service division. The new section will be concerned with diesel engines, diesel fuels and diesel fuel additives.

Desmond

After receiving a mechanical engineering degree from Pennsylvania State College, Desmond joined Ethyl and was engaged in automotive and aeronautical research projects at Ethyl's Detroit laboratories until he entered Navy submarine service in 1943. He rejoined the company in 1946 and was assigned to the aeronautical research laboratory, acting as liaison with the air lines and the U. S. armed services from 1949 to 1952.

Power Crane Association Annual Elects Smythe 1952 President

C. B. Smythe, president of the Thew Shovel Company, Lorain, Ohio, manufacturers of "Lorain" power shovels and cranes, was elected president of the Power Crane and Shovel Association at their annual meeting in Washington.

The Power Crane and Shovel Association is comprised of 16 manufacturers of power cranes and shovels in the classification known as "commercial sizes." "Commercial size" power cranes and shovels account for 80 percent of the dollar volume of the entire industry which will run approximately $350,000,000 for 1951.

Worthington Names Hutchinson As Middle Eastern Manager

J. R. Hutchinson has been appointed regional manager for the Middle East and will direct the Worthington Corporation's activities in Cyprus, Egypt, Greece, Iran, Iraq, Israel, Lebanon, Syria, Trans-Jordan and Turkey. An 18-year Worthington veteran, Hutchinson has served successively as application, sales and then field engineer in Worthington's pump, priorities, compressor and export departments. More recently he has served as a compressor specialist in the export department. He will be headquartered in Istanbul, Turkey.

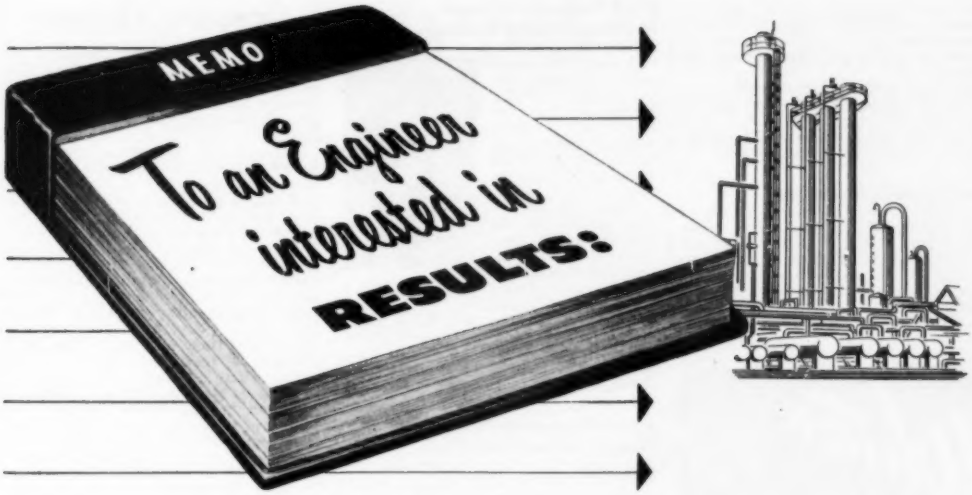
Celanese Corporation Announces New Chemical Division Office

The Chemical Division of Celanese Corporation of America has opened new offices in Chicago at 101 East Ontario Street. The Midwest district office was formerly located at the Merchandise Mart in Chicago.

Thomas G. Davis, district manager—Chemical Division, and G. J. Boyer, Midwest district representative, will be located in this office.

General Control Transfers Name Lindstrom and John Ferguson

John R. Ferguson, formerly manager of the Salt Lake City branch, has been appointed district manager of the Gen-



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With the application of the Dianodic Method, this entire system is now trouble-free. Manual cleaning of the system has been eliminated. More important, pitting and tuberculation have been completely eliminated.

The Dianodic Method is just one of many advanced developments produced by Betz Laboratories. It is the result of sound engineering and progressive research in water conditioning for over a quarter of a century. Call in a Betz Engineer today. Let him show you how you can obtain *results* in your plant. You'll be glad you did. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.

May we send you a complete report of the Dianodic Method of cooling water treatment? Ask for Betz Technical Paper No. 123.

BETZ

CONSULTANTS ON ALL WATER PROBLEMS

eral Controls Company branch office at Denver, and Herb Lindstrom, former Denver branch manager, has assumed a similar position at the Minneapolis branch.

Ferguson and Lindstrom will be in charge of all activities in their respective territories, including sales, engineering and service on General Controls' extensive line of automatic controls.

Don E. Sweeney Takes Over

Don E. Sweeney, formerly associated with General Motors Corporation, is the new sales manager of P&H's diesel engine division, succeeding R. H. Fitz. Having spent seven years with GMC as zone sales representative and zone sales manager, he brings a broad background of experience into the diesel engine field.

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Ole K. Olsen Co., 823 Perdido St., New Orleans, La.
Phillip D. Barnard, 2036 Addison, Houston 3, Tex.
Western Steel Prod. Co., 1735 W. 13th Ave., Denver 4, Colo.

BS&B Places Bill Williams In Charge of Sales Training

Williams

Bill Williams has been appointed as director of sales training by Black, Sivals & Bryson, Inc. The appointment places him in charge of sales training for all divisions of the company.

BS&B has a network of 52 branches and sales offices from coast to coast. Williams will headquarter at the company's Kansas City offices.

Formerly associated with Buick Motor Division, General Motors Sales Corporation, Williams was assistant zone manager, Kansas City. Prior to his employment by Buick, he was a special agent in the FBI.

Filtrol Corporation Plans New $5 Million Filtrol Plant

A new $5 million Filtrol plant will be constructed at Vernon, Calif. by the Filtrol Corporation, Los Angeles. The plant will manufacture ammonium sulfate fertilizer and high purity alumina, and will further process the alumina to produce alumina catalyst, stabilized alumina catalyst and impregnated alumina catalyst.

Construction on the plant is scheduled to begin during the fourth quarter of 1952 and completion is expected in the fourth quarter of 1953.

Chiksan Makes Service Awards; Four Receive Twenty-Year Pins

A total of 102 employes of the Chiksan Company were recently presented service certificates and tie clasps or pins in recognition of five years or more of service with the company. This number did not include those of the WECO division of Chiksan.

Twenty-year awards went to Frank Ellingsen, Jorgen H. Hansen, Van J. Kubin and Roy H. Bagby. Seven persons received 15-year awards, 23 received ten-year awards and 68, five-year awards.

Bigelow-Liptak Announces Formation Of New Subsidiary

Formation of a new subsidiary, Bigelow-Liptak Export Corporation, has been announced by Bigelow-Liptak Corporation. Organized to conform with the Western Hemisphere Trading Act, it will have main offices located in Detroit. Officers of the company are H. Stanley Ford, president; Richard E. Sampson, vice president and manager; Ernest B. Wolf, vice president; and Arthur L. Bert, secretary and treasurer. They also constitute the corporation's directors.

Houston Sales Office Moved by Carbide and Carbon

Carbide and Carbon Chemicals Company recently announced that their Houston district sales office has moved to Room 1201 of the new Prudential Building, Houston.

The Houston office, headed by district sales manager P. J. Doyle, was formerly in the Niels Esperson Building.

[Company Changes]

United Cooling Tower Company and **United Cooling Towers, Inc.**, have opened new office at 4022 Broadway, Kansas City, Mo. . . . **G. W. Huldrum, Jr.**, has been appointed sales manager, eastern division, Shell Chemical Corporation and **V. C. Irvine** has been named as western division sales manager. Huldrum, who replaces J. G. Frye, resigned, will supervise all sales activities east of the Rocky Mountains for Shell's solvents and other products. Irving, who joined the staff of Shell Development Company in 1934, fills the position formerly held by Huldrum . . . Owens-Illinois Glass Company has promoted **John Duncan, Jr.**, who has been with the company for the past 19 years, to director of trade relations . . . **Gardner P. Wilson**, a registered engineer in the State of California since 1948, has joined Consolidated Engineering Corporation as a senior development engineer. He will be in charge of the Mass Spectrometer Group of the engineering department . . . Bigelow-Liptak Corporation, Detroit, has announced the transfer of **L. E. Brungraber** from the engineering department to its sales staff in New York . . . The appointment of **R. L. Bernhard** as manager of the newly created centrifugal compressor department of the American Blower Corporation has been announced. Bernhard has more than 18 years of experience in the centrifugal compressor field . . . Wheelco Instruments Division, Barber-Colman Company, has announced the following personnel changes: **Richard K. Hungerford**, district manager of Baltimore office, transferred from New York; Gordon Hubbert, formerly in the Chicago office, now district manager in Detroit; **Howard P. Berger**, transferred from Baltimore to Cleveland; **Harold F. Dahlke**, transferred from Chicago to New York. The Division has also established three new district offices at: Grand Rapids, Mich.. **Robert P. Campbell**, district manager; Cincinnati, **Edmund C. McFaul**, district manager; Clarksburg, W. Va., **Earl J. Kelly**, district manager . . . Graver Tank & Manufacturing Company, Inc., has announced the opening of a Pittsburgh district sales office with **Robert E. Dunham** as resident sales engineer . . . **William W. Wingate** has been named as sales service representative of E. I. du Pont de Nemours & Company, Inc., petroleum chemicals division in Houston . . . Succeeding **Herbert A. Stanton**, retired, as president of Norton Behr-Manning Overseas Incorporated is **A. Donald Kelso**, executive vice president and director of that company. Kelso has been in the coated abrasives business since 1921 . . . **Alfred H. Milask** has been appointed eastern sales manager of Chemical Product Sales for The Atlantic Refining Company and transferred to the company's headquarters in Philadelphia . . . The Continental Supply Company, Dallas, has announced these appointments: **F. E. Amacker, Jr.**, manager of its Harvey, La., store; **R. M. Bynum**, manager of its Carthage, Texas, Store; and **J. L. Powell**, manager of its Liberal, Kan., store.

Franklin Moves Dallas Office

Franklin Supply Company has moved its Dallas, Texas office to 1428-30 Irwin Keasler Building. L. H. Strouse, vice president will headquarter in Dallas.

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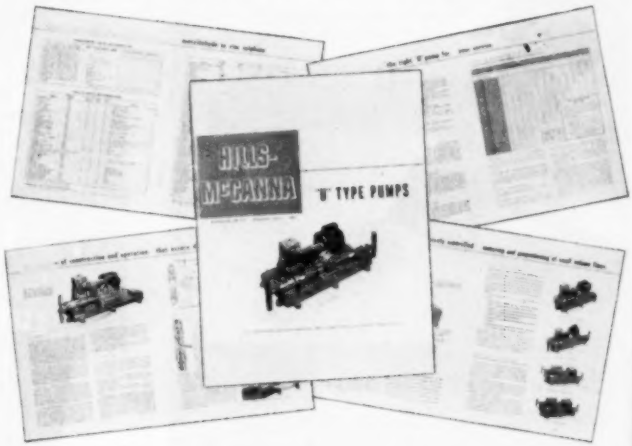
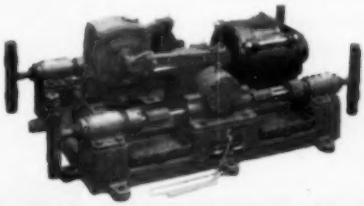
Here's a handy guide to the selection of metering and proportioning pumps



In this new catalog and pump selection manual for Hills-McCanna "U" Type Metering and Proportioning Pumps is all the information, including prices, for the selection of exactly the right pump for handling over 300 substances. Clearly and concisely, this helpful booklet gives all the necessary information and specific recommendations to cover the vast majority of needs that can be filled with a Hills-McCanna "U" Type Pump.

If your operations involve the metering or proportioning of small volume flows, you will find this catalog a useful addition to your files. We will be pleased to send you a copy on request. HILLS-McCANNA COMPANY, 2441 W. Nelson St., Chicago 18, Illinois.



Hills-McCanna "U" Type Pumps are reciprocating, variable stroke, mechanical drive units with maximum capacities ranging from 0.10 to 24 gph. per feed. One, two, three and four feed assemblies are available. Operating pressures up to 5,000 psi. A four feed unit is shown at the left.

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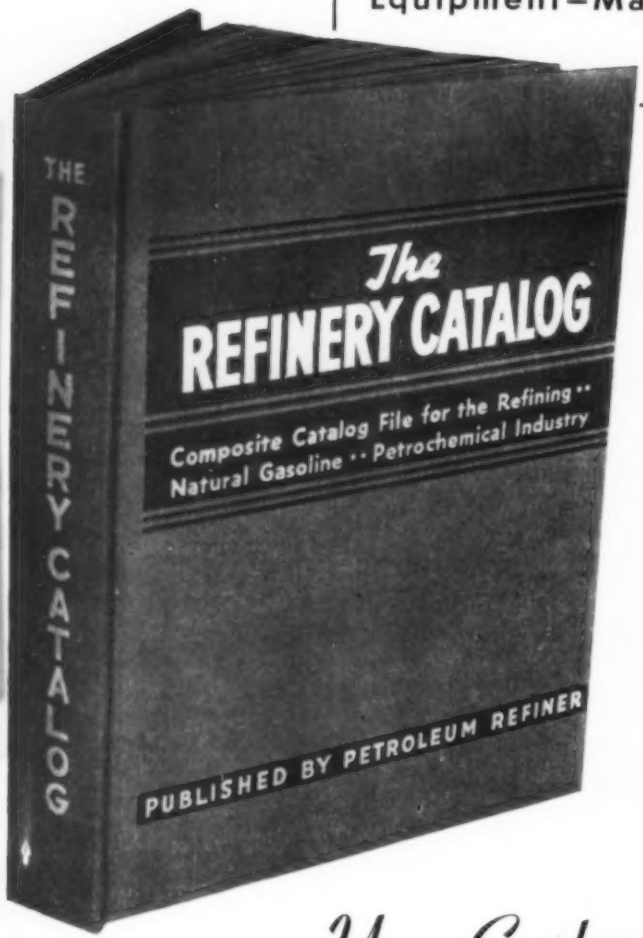
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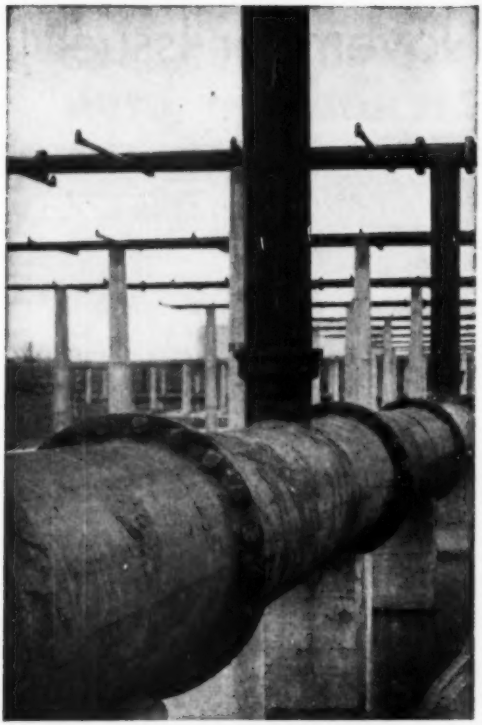

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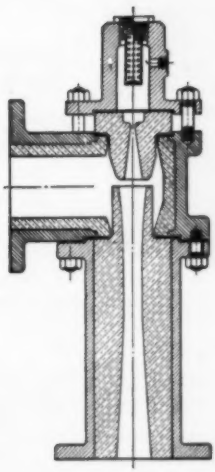

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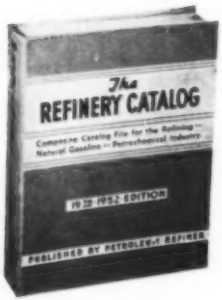

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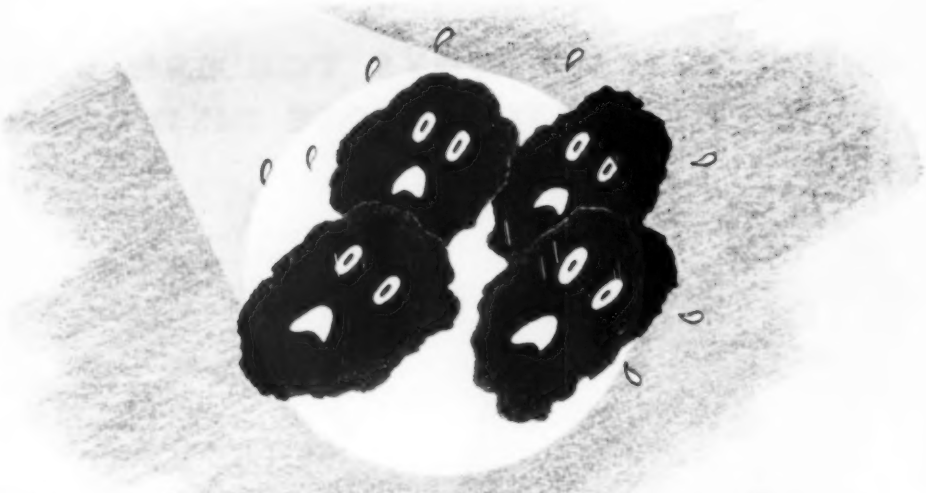

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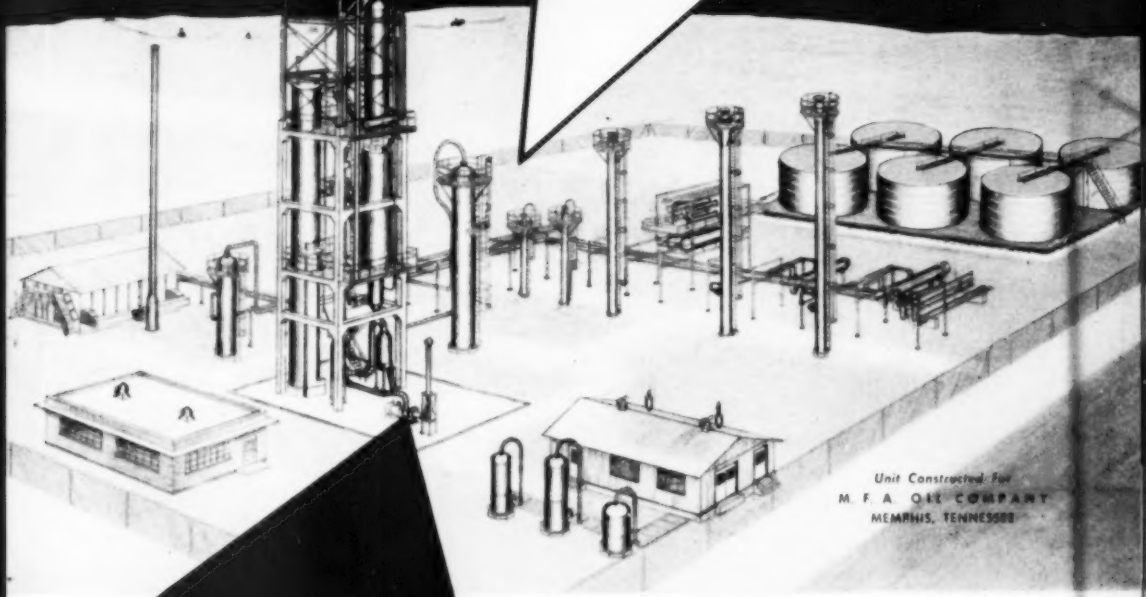

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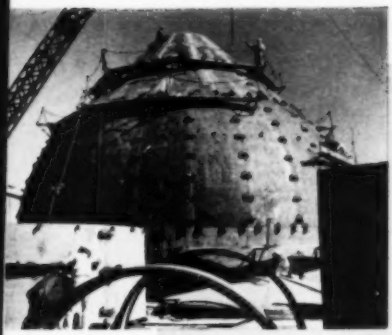

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